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Artificial Intelligence and Predictive Justice

Otri, Dania

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Artificial Intelligence and Predictive Justice

Dania Otri

Supervisor: Jean-Marie Jacquet (Signed for Release Approval - Study Rules art. 40)

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ABSTRACT

Much has been written recently about artificial intelligence (AI) in the field of justice. However, is it safe to let AI decide what is best for mankind? I would think not. AI can ease and pave the way to make a decisive and righteous decisions. Therefore, "AI needs social scientists to ensure AI alignment algorithms succeed, when actual humans are involved." (Geoffrey Irving & Amanda Askell). This thesis explains the function of the artificial neural networks and how it learns to make better decisions. Through a database processing and deep learning, ANN can determine the decision by comparing the case to similar cases using a dataset. AI is deprived from morals and emotions, thus it's able to give an objective decision. On the other hand, this might cause an ethical dilemma, therefore, there must be a human judge to give the final decision. In this study, AI judge would be applied on a collective settlements of debts case. The discussion aims to be nuanced but also understandable to those without a technical background. To that end, First, I'm going to discuss Justice in general, then turn to AI and how it's being used in the practice of justice and government officials, who administer the law. I've made two software to demonstrate the roll of AI in the field of law and justice. First software is Decision Making Assistant which calculates and gives results the judge needs to make the right decision. Second software depends on deep neural network that does all the calculations and present final decision without any intervention by a judge. Key motivation in writing this thesis is to provide a realistic, demystified view of AI that is rooted in the actual capabilities of the technology.

Keywords: artificial intelligence (AI), deep neural networks (DNN), predictive justice, decision making assistant and judge.

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INTRODUCTION

Decision-making is the most difficult step in the judicial process, so the application of traditional, scientific and quantitative methods are important in this process. As traditional methods related to judge's abilities, personality, experience and knowledge help to make good and safe decisions on time. Alas, these skills alone are not sufficient and must be based on scientific and quantitative bases that lead to make neutral and precise decision.

To take the right decision, the human judge seeks to study the data and information related to the case, which is usually a big amount to process. This makes the human mind incapable of limiting and studying it in an efficient and precise way. Intelligent systems are required to assist in decision-making or what is called artificial intelligence. When you use this science to develop a decision-making judiciary system, millions of pieces of information are stored inside the computer to form the main database. The same as storing information in the human mind through education, training and daily experiences. The computer can be used to store, classify and process this data to use it in a logical way for decision making. So far, scientists have succeeded in developing some small prototypes that include artificial intelligence in several fields.

In the judicial field, the use of AI technologies is currently being implemented in the US criminal court system. Where predictive algorithms are applied to access the risk of recidivism. For example, the probability that a convicted individual will commit another crime based on an evaluation of actuary data.
Dubai Courts are working to employ artificial intelligence in the judicial work. The purpose is to achieve speedy settlement of cases, facilitate procedures for dealers, reduce the burden on the courts, and also help to access data easily. It comes along with saving time and effort, providing security for documents and completing work anytime-anywhere. Artificial intelligence technologies also facilitate procedures for recording cases, paying fees, advertising, following up on sessions. This also allows participating in courts from the location of the customer while providing a great service to the lawyer that will save the lawyer from moving between the court buildings and halls. So the lawyer can follow all his/her cases in various courts from any location.

AI technologies may minimize the harm which is the product of human judgment. Conversely, the use of technology to determine whose liberty is deprived and on what terms, raise significant concerns about transparency and interpretability. We must consider both legal and ethical issues as well as engage in rigorous testing and evaluation routine to ensure the adoption of algorithmic tools to satisfy notions of procedural and substantive fairness, so that it doesn’t reinforce institutional biases.
Artificial intelligence, or what is known as the expert system, is characterized by being a comparative method to the human method of solving complex problems as it deals with hypotheses simultaneously, with precision and high speed. Perhaps the most important goal of converting to expert systems is the possibility of simulating human thought and its conduct.

The judiciary and the law enforcement are among the important areas that govern people and regulate their relationships with the society. An independent judiciary is always the most important part of every democratic government that deserves its name. It is inconceivable to have a government without a judicial system, and a government without an independent judiciary is always considered an authoritarian government. The judge must be loyal to his work, straightforward in his career, behavior, enjoying scientific competence, knowledge of legal and judicial culture, and always striving

to develop and improve it. Basic rules of ethics for judicial work are: independence, impartiality, integrity, discretion, courage, modesty, honesty and honour.

Imagine a court where a judge has a robot! It is not just science fiction anymore. This is already happening in Europe. For this reason, the European Council issued the first charter for the use of artificial intelligence in the judicial field. Unfortunately, the risks of predictive justice remain significant. The charter was adopted by the Council of Europe's European Commission for the Efficiency of Justice, known as CEPEJ, in December 2018 [1]. The charter is accompanied by an in-depth study on the existing use of artificial intelligence in judicial systems. The charter includes as well the recommendations on how artificial intelligence can best be used in this context and when its use should be considered with extreme caution. "Artificial intelligence is used to detect the risk of, the dangerosity of a person. Through analyzing a series of decisions again and data it will be able to tell you if a person is at low risk, medium risk or high risk of recidivism. This is also used in determining the duration of prison sentences," explains Clementina Barbaro, Head of Unit, Judicial Reform Co-operation, Council of Europe [2].

The use of AI has spread in many applications in medical, engineering and legal fields. One of the sections of AI is artificial neural networks, on which all modern and sophisticated applications are built, from robotics and decision support systems, automated control systems, recognition, prediction systems, and others. Artificial neural networks (ANN) are a mathematical, programmatic attempt to mimic the way the human brain works. It is characterized by its ability to predict the behavior of a large number of economic variables at one time, which necessitates its use in the economic and legal banking fields, such as analyzing the granting of loans in banks, settlement of collective debts, and so on. Through this thesis, we will discuss the **settlement of collective debts** using the artificial neural network, which is one of the models of artificial intelligence. **Debt settlement** [3], also known as credit settlement, is an approach to debt reduction in which the debtor and creditor agree on a reduced balance that will be regarded as payment in full. During a negotiation period, all payments by the debtor are made to the debt settlement company, which typically withholds payments to the creditors, even if the debtor has paid a lump sum or made payments. Once all the debtor's accounts are in default due to this non-payment, the debt settlement company has the leverage to force the debtor to accept a reduced lump sum payment as settlement. Otherwise, some debtors prefer this method of debt reduction over bankruptcy. ANN will predict the reduced value imposed on the debtor to be paid equally to the collective of creditors through mathematical equations. As preceded in this context, we will try to study the problem that presents itself and requires careful study to answer it through the following question: **What is the role of artificial intelligence in the decision-making process today and an ANN can be considered the best way to predict collective debt settlement?**

The rest of this thesis is structured as follows. Chapter 1 presents the reasons of robotic justice and the concept of predictive justice. Chapter 2 focuses on the definition and the categories of Settlement of Collective Debt. Chapter 3 shows the advantages of deep neural network. It describes all the structure, components, learn methods and activation functions of neural network. Chapter 4 demonstrates a software named, Decision Making Assistant and its requirements. It also explains the structure needed in order to support the creation of such a website. Chapter 5 applies the deep neural network in the field of predictive justice and reveals its mechanism and implementation. Finally, Chapter 6 provides vision for the future work that is essential in order to upgrade and improve the performance of the two software.

Chapter 1

ROBOTIC JUSTICE AND FUNDAMENTAL RIGHTS

1.1 INTRODUCTION

Traditional justice no longer meets the expectations of a society now oriented towards "customer satisfaction". The lack of efficiency and predictability, in particular, has pushed the European States, and Belgium in particular, to adopt a set of measures to revitalize justice.

In Belgium, the expected result has not been achieved, and even some negative effects have been observed. For example, the increase in procedural costs linked to certain reforms has certainly led to a reduction in the number of cases brought before the justice system, but also (and above all) to a reduction in access to the courts [4] and even to the exclusion of those who, because of their limited means, are no longer able to go to court and defend themselves.
The existing divide is thus aggravated, pushing even more people further away from a discredited justice system when it appears to be "unsuitable and unintelligible " [5].
As a result, initiatives to deploy algorithms for the provision of legal services have begun to multiply in the European area [6], at the initiative of the private sector, which sees this as a very promising new market. In this respect, the offer of legaltechs, start-ups specializing in the design of digital legal tools and services, is as wide and varied.

The introduction of the algorithm continues the process of computerization of the justice system, which provides better preservation of information and also facilitates access to and exchange of information. This first axis of computerization aimed at improving the support of justice to facilitate communication with the litigant, between the actors of justice, access to justice and the structuring of information. The second axis of computerization focused on the creation and development of various judicial databases, to gather information and better exchange. On the **qualitative** level, justice using algorithms is seen as justice offering guarantees of legal security by standardizing jurisprudence. It also contributes to better transparency of justice, by making it more accessible (by publishing all decisions) but also more objective by depriving it of bias and errors. Lastly, it enables the parties to better anticipate the judicial outcome of their case using a probability calculation (predictive justice). On the **material** level, it facilitates the work of legal professionals, in particular by automating repetitive tasks, and speed up the time taken to process cases. It thus leads to considerable savings in resources. At a time when the justice system is complaining of its destitution. But the use of **artificial intelligence** in the **justice system** aims to make it more logical, scientific and manageable according to some.

The fact today suggests that decision-making isn't necessarily reserved for a human judge. Today the question is, Can artificial intelligence replace a judge?
Indeed, the steps made in the field of artificial intelligence also affect the judicial field and those known as legalteach companies. They offer legal technologies and work to ensure that those involved in the justice system benefit from technology advances. As such, experiments tending to use artificial

intelligence as a decision-making tool are multiplying. For example, the test recently performed by two French courts of appeal which, for several months used the Predictive tool that predicts the outcome of a given case, using an algorithm that runs through all the relevant jurisprudence [7]. In the context of this experiment, artificial intelligence was limited to assisting the judge by providing an estimate of the decision that should be his. Whether or not he was inspired by the solution proposed by artificial intelligence, it was a human judge who was ultimately responsible for adopting the judicial decision.

The phenomenon of big data and artificial intelligence is provoking a "digital revolution". They bring modern society into a new phase, leading to the development of new services focused on the collection and processing of digital data. Like many professions, the legal professions are preparing for major changes as they come into contact with technological developments.

The present contribution aims to study the situation in which justice would no longer be dispensed by women and men but by a "digital judge" capable of making decisions without human intervention. The institution of the digital judge by law is not an obstacle. It is perfectly conceivable that the legislator could introduce automated decision systems for certain types of litigation. Even if the generalization of this type of instrument is more a matter of law fiction, it is the only hypothesis in which a robotized justice system could be imposed. Here is an example of Adoption AI in Chinese Courts, China says that millions of legal cases are now being decided by “smart courts” that do not require citizens to appear in court and includes non-human judges. China’s first internet court was established in the eastern city of Hangzhou in 2017. Users completed more than 3.1 million legal activities through the court system from March to October of this year, China’s official Xinhua news agency reported. It is designed to ease the workload of humans and improve the speed and effectiveness of the legal process. Court officials say that even though virtual judges are used, human judges observe the process and can make major rulings. People register their case on the internet and they can then take part in a digital court hearing. The system gives users the chance to communicate and receive court decisions by messaging services [8].

In order to answer the question in main Introduction, we are confronting digital justice with the most fundamental guarantees (the right to life, the right to a family life, to a fair trial, freedom of expression, religion and conscience) [9] granted to individuals by the European Convention on Human Rights [10] and by the Constitution.

Thus, our analysis focuses on the capacity of the digital judge to pronounce a decision that respects both the diverse facets of the right to a fair trial responding to institutional (independence and impartiality) and procedural (publicity, promptness, and fairness) guarantees.

1.2 REASONS FOR JUSTICE DECISIONS

The reasons for the judicial decision must enable the addressed parties to understand why their judge has made the decision. It also must be written in easily understandable terms that enable him or her to clearly understand the decision and its practical consequences. This is a heavy task because this requirement is sometimes difficult to reconcile with the use of precise legal terms, which are deemed necessary for the proper execution of the judgment.
The question of the motivation of justice decisions taken by a robot judge cannot be treated without making a theoretical distinction between judicial cases that we will describe as "simple cases" and other cases that we will describe as "complex cases".

1.2.1 Simple cases

This is the case where the judge is required to apply objective rules of law, characterized by a high degree of precision. For example, the case when the judge of the police court has to rule on the

existence or not of a speeding excess. In such cases, the application of the rule of law seems relatively easy: the Highway Code fixes a speed and exceeding it constitutes a fault.
Simple case processing can be done using ***artificial intelligence*** models called expert systems or rule-based systems. The **expert system** is a model of artificial intelligence, whose activity is framed by operating rules provided to the system. Otherwise, artificial intelligence applies rules that have been imposed on it by its designers. Thus, an expert system used to perform the activity of judging will operate the rules of law, which are relevant to solve a given type of case. For example, if an algorithm is in charge of imposing a sanction for speeding in resident areas, it will have as its operating rules the articles defining speed limits and the articles determining the sanctions for exceeding these limits. According to the article [11]: "Exceeding the maximum authorized speed determined in the regulations made in the present coordinated laws is punishable by a fine of 10 to 500 euros. The judge shall take into account the number of kilometers per hour by which the maximum authorized speed is exceeded". Such legal rules can be quite easily transposed into operating rules for the expert system. In concrete terms, the algorithm will abide to the following reasoning:

1) Speed X > threshold speed?
2) If yes, calculation of A = speed X - threshold speed
3) Depending on the value of A, application of the appropriate:
   Ex: If A > 20 km/h, application of the fine 250€
   If A > 30 km/h, application of the fine 350€, etc.

Note that, these instructions are not accurate because there are exceptional reasons to exceed limited speed like medical emergencies.
Faced with such a case, one can only note that the steps followed by the expert system are similar to legal reasoning. Moreover, this type of algorithm is capable of restoring different rules as well as the sequences in their application.

1.2.2 Complex cases

These are cases in which the judge is led to apply objective rules of law, characterized by a certain abstraction and vagueness. For example, the case when the judge must make use of standard concepts such as good faith, prudence, good father, fault, etc.
In the absence of a clear definition in the legal text, it is indeed for the judge to assess whether or not given conduct constitutes a fault. In such a situation, the margin of appreciation left to the judge by the legislature is particularly important. In such cases, another model of artificial intelligence known as ***artificial neural networks*** could be used to deal with these types of cases.
Artificial neural networks do not operate on the basis of a set of rules imposed on them but on the basis of a set of cases. If an algorithm of this type is used to make judicial decisions in a specific field, the base case will then be made up of judicial decisions pronounced in similar cases. This base of jurisprudence case will then be used to "train" the neural network. Once the neural network has been properly trained (achieving the objectives set) it can be used for resolving new cases, the base of jurisprudence case is used in the learning phase.

In concrete terms, the neural network will convert the data supplied into a signal as an input (digital value) which will propagate from one neuron layer to another until an output response is obtained. During this trip, the different neurons will (depending on the value assigned to their connection)

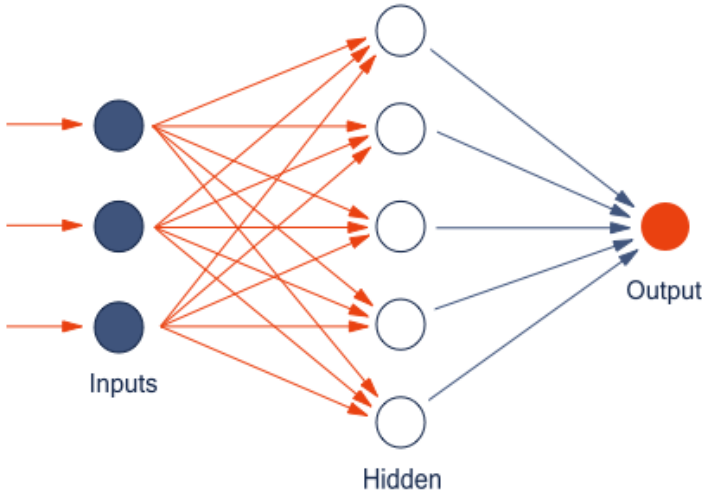


Figure 1: Schematic representation of an artificial neural network including an input layer (left), a hidden layer (center) and an output layer (right). The arrows represent the connections between different neurons.

decrease or increase the intensity of the signal. At the output, the intensity of the signal determines the decision to be taken [12, p. 44].

Artificial neural networks are not able to explain in a comprehensible way the steps and rules used to lead them to make a given decision. This lack of ability to justify decision-making makes neural networks a form of the black box. Thus, algorithmic judges would not be able to provide sufficient motivation for their decisions. In order to solve this problem. We are interested first, in the measures to be taken **before** the robot judge makes a decision and second, in the measures to be taken **during** the decision-making process.

- **Before the decision process**:

First, **rewrite the laws**: by taking into account their potential application, the machines modify laws in order to make them more easily applicable by expert systems. Thus, leading to limit the use of artificial neural networks, standard concepts (good faith, fault...) should be replaced by objective elements, in order to be processed by artificial intelligence which is able to motivate their decisions.

However, the replacement of standard concepts brings out questions about the evolutionary nature of the law and the creative role of the judge. Moreover, it is imperative that the adaptation of laws to their application by a robot judge be done by the legislator and not directly by the designers of artificial intelligence.

Second, **active advertising** may allow a better understanding of the functioning of the robot judge by the litigant. The transition from human justice to robotized justice may lead to a greater opacity in the functioning of justice. Confronted with a technology that is still little known and not very accessible, it's highly likely that the majority of litigants won't be able to really understand the processes underlying the operation of the robot judge. The use of active administrative advertising may become means of improving the understanding of the role of the robot judge and its function (mention of the algorithms used, explanation of their operation, details of database used during the learning phase, etc.).

Finally, although the use of active advertising may help to improve the understanding of the robot judge by the litigant, this measure alone is not capable of compensating for the lack of capacity to reason for decisions taken by expert systems.

Third, **audit**, Algorithms which are being considered for use by courts and tribunals should be subjected to a prior hearing by an independent authority composed of artificial intelligence specialists, with the assistance of judges in matters relating to the relationship between artificial intelligence and the judiciary.

Such an audit would ensure that any algorithm used for judicial decision-making would be able to deliver a sufficiently logical judgment.

- **During the decision process**:

Right to an explanation, if the artificial intelligence is not capable of providing by itself a decision whose reasons are easily understandable, it is conceivable that the judgment recipient may nevertheless be able to obtain an explanation.

An example is provided by the European Regulation on the protection of individuals with regard to the processing of personal data [13]. Thus, Article 22 requires Member States to provide certain safeguards for persons undergoing automatic data processing. The processing by a robot judge of data is necessary, for the adoption of judgment falls within this definition. Among the guarantees: obtaining an explanation of the decision taken.

1.3 INDEPENDENCE AND FAIRNESS IN DIGITAL JUSTICE

Independence: in the legal dictionary is defined as "the state of a person who works without being ordered, who acts without being acted upon, in accordance with ethics and deontology" [14]. Independence must be considered in relation to political, economic and social pressure categories. The influence of the digital tool remains limited by the judicial power of the judge. When a digital tool is the judge, there is no longer a filter between the digital service provider and the author of the jurisdictional act. It is the algorithmic system that produces the decision. The question of the independence of the "judge" in this context becomes absolutely crucial and must be carefully criticized. The question is being increasingly raised at present since the State no longer finances certain computer tools used by the judiciary. The Court examines the internal independence of the judicial system. This requires judges to be free from pressure or influence from colleagues or heads of corps.

Fairness: is the neutrality of the judge. He cannot take sides for or against one of the parties. The examination of a judge's fairness will focus first of all on his or her behavior, on the way in which he or she expresses or does not express certain biases. The benevolent external observer, examining the organization of the court and the conduct of the proceedings, cannot have any doubts about the fairness of the court: "justice must not only be done but must also be seen to be done".

Independence is rather attached to the status of the judge, while his impartiality is a quality

1.3.1 Independence in digital justice

On the first hand, the idea of a computer system that would rely on previous cases to make decisions is not contrary to the Convention. On the other hand, the financing and control of the digital tools made available to the judiciary is a central issue, even when it uses research tools developed by a considered private sector. Unless the State has sufficient financial means to develop its own systems, the implementation of judicial decision-making systems will have to be carried out by the private sector [15]. When the justice system is under external influence, the independence of the judiciary can still be questioned. The company that creates the algorithm can perfectly well bias it, with good

intention or not. But what guarantee do we have that the author of the system is not himself under influence and does not pursue foreign ends to the work of justice?

1.3.2 Fairness in digital justice

Many judicial decisions are influenced by the judge's prejudices, resulting from his or her experience, social background or education. Judges may be victims of cognitive bias: they may misunderstand facts or attach too much importance to some rather than others. They may also be emotionally dependent. The computer shows no emotions. It is indifferent to the characteristics of the people it judges. It always decides in the same direction, in a given factual context. The neutrality and consistency of the machine are therefore characteristics often put forward by defenders of algorithms to support that the 'fairness' of the computer is greater than that of the judge. This view is, however, a bit short, because the use of a digital judicial decision system actually poses serious problems in terms of fairness.

1.4 ROBOTICS AND ACCESSIBILITY OF JUSTICE

At first sight, a robotization of justice could help make it more accessible. Three main arguments can be developed in this sense.
Reduced costs: the progressive replacement of human judges by robot judges suggests that a reduction in the cost of justice would be possible. This cost reduction can be explained by two major factors. First of all, **theoretically**, **null cost of use**: there is no cost of using the application and **less time**: in case of similar cases, the robot judge takes less time and effort to predict the decision. It should be noted that for the same number of cases handled, a robot judge is much less expensive than a human judge [16].
Moreover, the use of justice rendered by algorithms would, in many cases, lead to the abandonment of the physical dimension of the trial. The number of hearings would decrease. It is understandable that these savings would result in a reduction in the cost of the proceedings.
Taking in consideration, the cost of the application program, the cost of developers, the number of users of the program, the model of the operating system and training of persons.

Availability: an algorithmic judge can perform his or her function on a permanent basis, for example, if access to the algorithmic judge was provided via an online dispute resolution system. In such a configuration, the courts could be considered more accessible because they could be available at any time by the litigants (unlike the human judge).
Speed: the robot judge is able to process the requests submitted to him faster than the human judge, especially when they are repetitive resulting in a reduction in judicial time, which would be an advantage for the litigant concerned by the case being dealt with.
Moreover, the processing of the simplest cases by robotized justice could allow human judges to devote more of their time to the resolution of the most complex cases. Most importantly, justice will be served swift.

1.4.1 Robotization and Risks for the Accessibility of Justice

Two elements fuel the promise of accessibility brought by the robotization of justice.
Cost of robotization: While the reduction in costs is engendered by greater use of robotic judges seems undeniable in the long term, we must nevertheless question the extent of the sums that will have to be invested to implement this new form of justice.
Unequal access: When public authorities make use of "new" technology, the transition from human justice to robotic justice is likely to create inequalities of access among those subject to justice. Indeed, it seems obvious that digital dispute resolution systems are a priori only accessible to people

who have the appropriate equipment and who is computer literate, i.e. who have sufficient skills to use these systems. Clearly, such a situation leads to a widening of the digital divide [17].

1.4.2 Accessibility of Judicial Databases

The establishment and proper functioning of a robotized justice system cannot be contemplated without the creation of large judicial databases. This is particularly true for robotic justice systems that are operated by artificial neural networks.
The creation of judicial databases in **Belgium**: The question of the creation of judicial databases is above all, a question of the availability of the jurisprudence produced by all the courts and tribunals [18]. Information system provides, however, the external jurisprudence database (accessible to the public) contains only judgments and decisions previously selected by the courts that give them.
Article 782bis of the Judicial Code was amended by the Law of 5 May 2019 to allow the registration of all Belgian judicial decisions in a publicly accessible database. The accessibility of this database still need to be defined by the legislator.
These databases were not only designed to store or retain information but also designed to allow cross-referencing of information and comparison between different facts or different authors, thus creating links.
So, as far as the possibility of algorithmic justice is concerned, the lack of publication of court decisions is a major obstacle to the development of the robot judge. Indeed, the use of artificial neural networks is, as we have seen, conditioned by the existence of jurisprudence databases on which neural networks will be able to carry out their learning phase. A neural network operating on the basis of a biased data set could not give satisfactory results, because it reflects only a tiny part of the Belgian jurisprudence production.

1.5 PREDICTIVE JUSTICE AND ALGORITHM

At a time when the justice system is complaining of its destitution. The development of technology tools invites us to take seriously the subject of the robotization of justice and the integration of the algorithm in the decision-making process. The use of artificial intelligence to support or determine a judicial decision is no longer science fiction.
But the use of **artificial intelligence** in the **justice** system would also aim to make it more logical, scientific, and manageable according to some.
The concept of **predictive justice** has two conceptions that should be distinguished: **analytical justice** and **anticipatory justice**.

1.5.1 Analytical justice

Analytical Justice tries to anticipate through the analysis of previous decisions, what the decision of a court will be. Based on the use of big data, this technology proposes to examine a given situation through the filter of jurisprudence databases to evaluate the possible outcome of legal action. This method is based on a calculation of probabilities. Currently, many companies are working on developing new tools to determine the outcome of legal action. In the United States, IBM has developed the ROSS software which is already used by many law companies [19].
More directly oriented towards law, work carried out on the basis of the latest technological developments in the fields of automatic learning and language processing, has led to the development of algorithms with promising results.
The work carried out in 2016 on the jurisprudence of the European Court of Human Rights by a team of researchers (in computer science, psychology, law and information science) has led to the creation of a software capable of guessing court decisions by integrating positive law, facts and arguments of the parties, with a rate of relevance to human decisions of almost 80 percent [20]. This

experimentation focused on the litigation of cases relating to articles 3 (prohibition of torture and degrading treatment), 6 (right to a fair trial) and 8 (right to privacy) of the Convention.

1.5.2 Anticipatory justice

It promises to assess, using computer tools, the dangers of a given individual or the risk that he or she will reoffend. Various experiments have been conducted in several countries to test computer systems for processing and analyzing data, in order to better predict the criminal history of individuals. Whether to measure a risk of recidivism or to assess the need to place an individual in pretrial detention.
In the United Kingdom, the Durham Police is currently testing a program called the Harm Assessment Risk Tool (HART), which is designed to determine whether or not a suspect should be returned to a rehabilitation program. Developed by the University of Cambridge, this artificial intelligence software is designed to predict whether suspects have a more or less risky profile of committing a crime within two years. It is based on some 30 factors such as age, sex, criminal record and postal code. Currently in the testing phase, it presents results that are only partially shared by human analysis, since in nearly 50% of cases, man and machine did not evaluate the dangerousness of a suspect in the same way [21]. However, the result delivered by the program is only an aid to decision making, and it is good that the human, whether or not based on the conclusions of the machine, makes the decision.
The results of forecasting techniques are still not very convincing and are met with some reluctance by judges who use them because they doubt their relevance and are somewhat apprehensive about them: these methods only produce profiles and behavioral models with no guarantee of reliability. Perhaps tomorrow these software programs will be more efficient.

1.5.3 The impact of the results produced by the algorithm

"Judicial decision-support tools must be designed and perceived as an auxiliary assistant to the judge's decision-making process, facilitating his or her work, and not as a constraint", advocates the European Commission for the Efficiency of Justice.
This implies that the result provided by the software can only be considered as an assistant to the decision, a suggestion which could not in any case bind the judge. But even if the result is only a suggestion, the risk exists. The results produced by high-performance tools could in fact no longer be experienced as merely indicative or incentive but as prescriptive.
This leads to the following question: Will the algorithm be fairer than the judge? It will probably be more consistent, in some ways more objective, less subject to irregularity or variance. It will not be influenced by external factors that could pollute the decision-making process (judge fatigue, ideology, etc.). But to believe that an algorithm would be neutral is naive. Experiments already carried out prove it sufficiently: prediction or decision-support programs simply calculate the solution of an equation whose formula has been developed by man, by favoring or minimizing some factors, according to the conscious or unconscious convictions of the developers.

1.6 ARTIFICIAL INTELLIGENCE IS FRIEND OF THE JUSTICE: TRUE OR FALSE?

New applications are emerging which make development possible. It is reasonable to expect that this software will be further developed and, in time, integrated by lawyers into their daily practice. It is clarified that the term "law professional(s)" does not refer to judges but to other actors in the world of justice, for instance, lawyers, law insurers and law consultants who are exploiting the potential of digital technology, more often referred to as **legaltechs**.

1.6.1 The Use of Artificial Intelligence in Law Related Professions

- **The advent of big data**

In the judicial sector, extensive case law databases have been built up over time. These databases have diverse origins.
First of all, there are public databases, such as the (Juridat) platform [22], which is well known to Belgian practitioners. At the same time, private operators offer jurisprudential databases of a thematic nature. Some of them are accessible for a fee.
Finally, various organizations (public [23] or private [24]) have a large body of case law documentation relating to the litigation in which they regularly intervene. From this documentation, these operators can build up thematic databases, which allow them to develop their arguments and enrich them as the jurisprudence evolves.
In a way, these bodies have tools that help them to "predict" the outcome of litigation by referring to the case law precedents stored in their databases, whether or not these cases are favorable to them.

- **The open data of jurisprudence**

The phenomenon of big data has given rise to an **open data** movement, which is reflected in a desire to provide free and open access to all case law. Judicial open data is a modern way of guaranteeing the principle of the publicity of cases and ensuring non-discriminatory access to it. This principle of open data of jurisprudence was implemented several years ago at European level. As a result, the decisions of the courts of the European Union are freely and fully accessible online [25]. At national level, the implementation of the open data principle is more complex.
The Belgian authorities have recently taken an important step forward by adopting the open data principle.

- **The emergence of AI**

The data collected is of no real interest if it’s not analyzed and interpreted. The phenomenon of big data has so far favored the development of artificial intelligence, which includes all the computer processes that enable machines to produce information processing that is close to human intelligence. Artificial intelligence techniques make it possible to extract a maximum amount of information from data and give it coherence, using algorithmic tools. The task of these tools is to list, sequence and organize the classification of the data, based on various predefined criteria, in order to identify correlations between groups of data thus created and to identify trends. The work of these tools is based in particular on a semantic analysis, centred on the examination of the terms used in the legal decision. The use of these algorithms makes it possible to process much greater volumes of information that are accessible to human intelligence, which helps to detect new phenomena and to envisage solutions that are sometimes original for the practitioner.
Artificial intelligence is also characterized by a phenomenon of machine learning, which allows the computer tool to improve itself through experience, by analyzing the behavior of its users to autonomously develop its capabilities and adapt to their expectations. In the judicial sector, it is in the field of judicial research that the concepts of big data and artificial intelligence are showing their first results. Legal advice could also be revolutionized by the arrival of this new technology, which offers a glimpse of the ability to predict the solution to a given problem.

1.6.2 The Use of Artificial Intelligence in the Practice of Law

- **Artificial intelligence and judicial research**

As has been pointed out, the jurisprudence databases available to law practitioners are increasingly numerous. Today, there are no longer any real limits to the storage capacity of case law platforms. In order to remain efficient, legal professionals must equip themselves with adapted and powerful search tools that enable them to extract information relevant to their practice. The use of search engines whose efficiency is correlated to the size of the databases becomes essential in order to be able to

meet and usefully take advantage of the big data phenomenon. This implies the design of algorithms that integrate and understand the main parameters of legal research.

- **Artificial intelligence and juridical monitoring**

Artificial intelligence is connected to the phenomenon of open data that allows the creation of juridical monitoring instruments, which are capable of proactively assisting law professionals in the management of their knowledge. It is indeed possible that a case management software can cross-reference the content of a judgment with certain files, based on the analysis of keywords.
This type of application seems quite accessible to the intelligence industry, since it is only a question of carrying out a textual analysis of certain contents and identifying correlations between keywords.

- **The role of legaltechs**

The emergence of modern instruments that exploit the capabilities of algorithms and big data could change the work of many legal practitioners. However, the legal professions have been cautious, even reticent, at the beginning, about the development and the use of artificial intelligence.
Computer professionals play a role that first contributed to offering innovative services combining the use of new technologies and the practice of law. Some legaltechs (start-ups) offer their services to legal professionals and provide them with tools that enable them to strengthen their skills. Other start-ups compete directly with legal professionals by offering their clients an automated legal service at a reduced price.
Legaltechs take advantage of the difficulties encountered by the traditional legal professions and respond to the criticisms regularly levelled at them (cost control, accessibility of the law, predictability of results, etc.). They thus give the impression of democratizing legal services and making them more accessible. It should also be noted that these legaltechs are above all profit-driven. Faced with this observation, legal professionals are led to review their practices, making the issues of big data and artificial intelligence a priority. Today, it seems essential to assimilate and integrate new technologies into the practice of law, rather than trying to oppose them.

1.7 CONCLUSION

The classic fair court model is being undermined by the digital world. New predictive justice procedures are emerging that are completely outside the traditional patterns. Several authors are fighting for the creation of new fundamental rights, more adapted to the digital world. The goal is to avoid the actors of the digital world passing into danger, taking advantage of the limits of classic fundamental rights. In this respect, it is striking that the concept of transparency is mentioned in many studies as a condition for the fundamental validity of any automated decision-making system. It is a cross-cutting issue and overlaps with various rights such as the obligation to give reasons for judgment, the independence and impartiality of the judge. The observable and verifiable nature of the judicial process has always been present in the concept of fair trial, but the challenges posed by algorithmic justice call for greater attention, due to the particularly opaque nature of the procedure (especially with regard to artificial neural networks). Transparency thus sums up in a single concept different concerns of fundamental rights in procedural matters and becomes one of the fundamental requirements of the digital justice universe.

The algorithm could be used as a decision support tool, and we should not be afraid of this development, because it is likely to be cheaper, more "cost-effective" and more "objective" or "neutral". The use of big data will indeed require monitoring its own tools and transparency of its operating modes, which will generate new forms of expertise and control. New institutions will be created to provide support in areas, where society needs to examine big data results. These new institutions will have to be independent of software developers and be under the control of public authorities, so that quantitative change does not cause qualitative change.

After all, is artificial intelligence a true or false friend of justice?
No, AI is not necessarily a false friend of the justice, if the tools of artificial intelligence are used by law professionals for what they are, taking into account the limits and risks they present. We must ensure that human intervention remains predominant. Under these conditions, undoubtedly a reinforcement of transparency and freedom of choice of the litigants as regards the use of AI, one can normally remain confident in the future of legal expertise, increased by digital technology, as long as it remains, first and foremost, human.
In the next chapter we will explain a case of study that talks about settlement collection of debts.

Chapter 2

THE SETTLEMENT OF COLLECTIVE DEBTS

2.1 INTRODUCTION

Many people wish for a plan that protects their social status. Help comes from legislative intervention through the judiciary and the mediator. The debtor and his family must stay fit in terms of human dignity until the debts are paid back to the creditors.

At this phase, the problem of over-indebtedness affects every society today, as it has for some time now, a large number of people, in particular employees and people without a profession who are worried and suffering from a series of debts and can no longer face up to growing debts. The rate of people is increasing in their call to find a solution that could solve their problem towards an effective and active procedure.

The legislator has decided to adopt a law that makes it possible to solve their problems through a system known as the **settlement of collective debt** under the Belgian law of July 5th 1998, which entered into force on January 1st 1999, and is included in Part 5 of the Judicial Code [26]. This system aims to reassure the assistance of over-indebted people who face heavy financial problems in their lives and in order to meet specific needs in the general interest.

2.2 THE ROLE OF SETTLEMENT OF COLLECTIVE DEBTS

A settlement of collective debt aims to restore the debtor's financial situation and, as far as possible, to enable him to pay his debts in return for ensuring that he and his family can lead a life in accordance with human dignity [27].
Collective debt settlement can take two forms: the **amicable** method, where the parties agree on the details, amounts and other matters in a way that best suits them; or **judicial recovery**, imposed by the judge on all parties after they have failed to agree [28].

2.2.1 Elaboration of the judicial settlement plan

Once, the over-indebted debtor deposits a demand (called a request) for a collective settlement of debts, according to Article 1675/6 paragraph 1 [29], the judge will have to decide for eight days on admissibility. Once this decision (called the admissibility order) has been made, the judge must appoint a debt **judicial mediator** [30, p. 22]. The law allows the debtor to propose in the request the name of a debt mediator. However, the judge is not obliged to follow this proposal and may appoint any other person.
In this eligibility in which the judge appoints the **judicial mediator**, the requestor receives a registered letter that mentions the name and contact details of his or her judicial mediator. The debtor

must quickly contact his mediator to arrange a first appointment to discuss his income and set determined payment from the date of the judge's decision.
The **mediator** has an infinite choice of possible proposals to submit to the creditors, and fortunately, the majority of cases result in the establishment of a project for an **amicable** plan and the approval of this agreement by the court, according to Article 1675/10, paragraph 5 of the Judicial Code [29]. Belgian legislation must intervene to set a time limit either for the amicable plan or for the judicial plan, because, it is not normal to leave the debtor to be condemned to repay until the end of his days. At this point, the legislator intervened in its Article 1675/12 paragraph 2 of the Judicial Code [29] which specifies "the duration of the judicial collective settlement plan may not exceed **5 years**".

- **The task of the judicial mediator** is not to defend the debtor in front of his creditors but to find an agreement with them to pay off their debts while allowing him to live with dignity. Even if the judicial mediator is a lawyer, he/she is not a lawyer or social assistant. The mediator must be neutral and impartial. He cannot take sides for debtors or the creditors. He acts under the control of the judge who chooses him.

- **the judicial mediator appointed in four categories**
  According to Article 1675 /17 paragraph 1 [29], the debt mediator can be appointed as:
  - Approved debt mediation services
  - Lawyers.
  - Notaries.
  - Bailiffs.

  These persons may act as debt mediators and will have to be approved by the competent authority.

2.2.2 The persons can be benefit from the law of collective debt settlement

Who is the law on the settlement of collective debts addressed to? In other words, can anyone who is having financial difficulties ask for a collective debt settlement? In fact, the law on the collective settlement of debts applies exclusively to:

1) Natural persons, who are passing from situations of over-indebtedness and who are not or no longer traders (companies, businesses... etc.) and who have not obviously organized their bankruptcy [31].
   According to the commercial law, the person exercising a profession (doctor, lawyer, architect...) does not have the status of a commercial trader and can benefit from the procedure in the same way as salaried persons and persons without a profession [30, p. 12].

2) Persons domiciled in Belgium, whatever his/her nationality.

3) No longer be a businessman (commercial trader).
   According to Article 1675 paragraph 2 [29], a trader who has been out of business for more than **six months** may benefit from the collective debt settlement procedure.

When only temporary financial problems are involved, for instance, due to loss of employment or separation of body, it is better to first ask the creditor for payment deadlines. If he refuses, it is possible, under certain conditions, to ask the judge to grant such payment periods according to the procedure of collective settlement of debts provided by Law No57 of 5 July 1998, by its article 1675/2 paragraphs 1 and 2 of the Belgian Judicial Code of 2004, which provides that "Any natural person who is not a commercial person within the meaning of Article 1 of the Commercial Code may, if he is not in a condition, on a permanent basis, to pay his debts due or still to fall due and as far as he has not manifestly organized his insolvency". And according to Article 1675 /4 paragraph 1, the

requestor must introduce, in front of the judge of the court, the request for a collective settlement of debts.
The debtor may, according to Article 1675/4 [29], introduce a request for settlement of collective debts through a request. The documents to be attached to the request shall be deposited or forwarded in double copies.

- **The request includes the following statements:**
    1. The last name, first name, date of birth, national register number and address of the requestor, as well as, where appropriate, the last name, first name, address and capacity of his or her legal representatives.
    2. The identity of the proposed mediator.
    3. The last names, first names, address and date of birth of the applicant's partner or of the persons living with the applicant.
    4. The reasons for the impossibility of repaying debts.
    5. The debts that are contested in whole or in part and the reasons for the contestation.
    6. The signature of the debtor or his mediator.

The law concerns all people who are having serious financial difficulties, who can no longer, with their income, meet all their debts.
These insolvent persons are no longer, as the law provides, in a position, on a lasting basis, to pay their debts.

2.3 THE CATEGORIES OF COLLECTIVE DEBT SETTLEMENT PROCEDURE

There are two possibilities in the collective debt settlement procedure:
An amicable procedure: The judge appoints a debt mediator, who tries to negotiate an amicable plan with the creditors.
Non-judicial debt mediation (amicable mediation) is individualized assistance provided by legally appointed persons (lawyers, notaries or bailiffs) whose task is to negotiate debt settlement plans, particularly for debts relating to credit contracts, and to ensure that payment deadlines are met.
In the case of disagreement, according to article 1675/3 [29] which says that "if no agreement is reached on this amicable settlement plan, the judge may impose a judicial settlement plan". Therefore, the mediator asks the judge to impose a judicial procedure.

A judicial procedure: In the absence of agreement between the debtor and his/her creditors, the judge may impose a judicial plan. At this step, article 1675/3 [29] provides that "The debtor proposes to his creditors to make an amicable settlement plan through a collective settlement of debts, under the supervision of the judge. If no agreement is reached on this amicable settlement plan, the judge may impose a judicial settlement plan. The purpose of the settlement plan is to restore the debtor's financial situation, in particular by enabling him or her to pay the debt as far as possible and at the same time guaranteeing him and his family that they will be able to lead a life in accordance with human dignity".

2.3.1 The role of the debt mediator

The role of the debt mediator can be considered in the following cases:
The mediator must try to reach an agreement between the creditors and the debtor to repay his debts. It prepares the debt settlement for firstly negotiating with the creditors amicably in parallel respecting the living conditions that conform to the human dignity of the debtor and his family. And according to article 1675/ 11 which provides that "When the mediator finds that it is not possible to reach an agreement about a plan of amicable settlement within six months of his appointment, he records it in a **deficiency** report which he transmits to the judge with a view to a possible plan of judicial settlement".

If the judge accepts the judicial settlement plan, the debt mediator must open an account in the name of the debtor at the beginning of the settlement procedure. This account is called the **mediation account** or **mediation pécule**, where all the debtor's income should be paid into this account (his salary, unemployment benefits, social assistance, family allowances, also maintenance contributions, tax refunds, medical reimbursements, social allowance reimbursements and inheritance etc.). And according to article 1675 /17, the mediation pécule will be fixed by the mediator in agreement between the debtor and the creditors, either within the plans of amicable or judicial settlement granted by the judge of the court.

The mediation account (pécule) will be available to the mediator during the period of preparation of the amicable or judicial plan. The savings are therefore considered as a global strategy plan that will allow the debtor to cover, during the execution of the amicable or judicial plan, his current expenses and to ensure his daily life in conformity with human dignity in Belgium.
In this regard, according to article 14 of the Act of 26 May 2002 on the right of social integration increased by the amount of family allowances and according to article 1410, paragraph 2, of the Judicial Code, the monthly pécule may never be less than the minimum integration income [30, p. 19] and the debt mediator with the money in the mediation account, will promise to pay the monthly amount on time at the agreed dates determined in the amicable or judicial settlement plan.
According to Article 1675/13ter [29] of the Judicial Code, the monthly pécule must be determined on the following data of the over-indebted person (age, family situation, work history, state of health, cooperation with the mediator, motivation) with respect for the equality of creditors.
According to Article 1675/17 paragraph 3 [29] of the Judicial Code, however, this pécule must be sufficient to enable the over-indebted person to lead a life in accordance with human dignity.
So, on the basis of the debtor's available sources, the debt mediator has to establish the **budget** of the over-indebted person, i.e. the ratio between the debtor's income and expenses. What is left of the income, after deduction of the current expenses (rent, water, electricity, food, etc...), will be the **available**. This will be used to pay off debts. The mediator will organize a repayment plan that covers all the debts of the debtor's creditors. This **available** amount must be paid each month.

The available = The income - The pécule

The goal of the debt mediator is to help the over-indebted person to pay back his debts to the creditors through monthly payments (pécule) [30, p. 10]. Also, even for the costs of the mediator, the debtor must normally pay these costs according to article 1675 /19 of the Judicial Code [29]. However, sometimes, in cases where the debtor is insolvent, the debt mediator may request the intervention of Federal Public Service Economy [32].

2.3.2 Debts that can be repaid

The mediator takes care of repaying the debtor's creditors through the **available**. All the debts of the debtor without any exception are included. All the debts of the over-indebted person must indeed be handled at the same time without distinguishing between creditors.
According to article 1675 /12 paragraph 5 of the Judicial Code [29], the **available** covers all necessary debts, whether due or to become due, of a private, professional, tax and alimentary, etc.
The task of priority repayment of debts falls on the judge and the debt mediator, for example, among the debts to be repaid, alimony payments are paid faster than other creditors. And to avoid the risk of eviction of the debtor from his apartment, the debts relating to the rent must be paid in priority, and debts of energy bills must also be paid to avoid a cut during the winter [33].
During the execution of the plan, the judge will also check if the accompanying measures or conditions of the judicial plan are respected by the debtor (the beneficiary).
The mediator submits his annual report to the judge.
Every year, however, the mediator must also send to the debtor a report of his mission, which must indicate the balance of the account, as well as the details of the operations carried out on the

mediation account. And according to article 1675/9 [29], the debt mediator is allowed to request information from the debtor, as the creditors and from third parties, for example, (a bank, a notary, a bailiff ...). However, the debt settlement plan may be subject to revocation by the judge during the application of the plan.

2.4 REVOCATION OF THE COLLECTIVE DEBT SETTLEMENT PROCEDURE

According to Article 1675 /15 paragraph 1 [29], during the period of the judicial or amicable plan, if the judge finds that the over-indebted person has hidden part of his assets or has presented false information about debts, income, or the debtor does not fulfil his obligations to the debt settlement plan without giving reasons, the judge may cancel the repayment plan with consequences that the creditors may again take the assets and income from the debtor [30, p. 52].
If the amicable or judicial settlement procedure has been revoked, according to the application of the above mentioned article, the debtor may not make a new request for a collective debt settlement during a five-year period from the date of the revocation judgment.
However, in the case of a settlement plan with debt remission, the revocation of the plan remains possible for a period of 5 years after the end of the plan if any fraudulent behavior of the debtor is discovered.

2.4.1 Total debt remission

What are the conditions for total debt remission?
In Belgian law, debt remission is considered as a means of extinguishing obligations.
Total debt remission can be extinguished by several types, such as the following:

1. **First type:**
   According to articles 1282 and following of the Belgian Civil Code, the total remission of debts can be made by a common agreement of two parties. This agreement can extinguish debts by two essential elements:
   - The voluntary remission by the creditor to his debtor of his debt.
   - Acceptance of the remission of debts by the debtor, even tacitly.

   According to the rules of the above-mentioned articles, debt remission is a contract by which the creditor voluntarily releases the debtor from all or part of his debt. That is to say, the remission may relate not only to the principal debt but also to the accessories of the debt such as (interest on arrears and damages). In this case, it is a complete cancellation by the creditor.

2. **Second type:**
   The total remission of debts is possible by a judicial or amicable plan accepted by the court judge.
   According to Articles 1675 /13 paragraph 3 and 4 of the Judicial Code [29] approve that the judge of the collective debt settlement could grant the remission of debts of the debtor by the proposal of the mediator. The judge may not grant remission for the following debts:
   - Maintenance debts.
   - Debts consisting of compensation for personal injury caused by an offence.
   - Debts of a bankrupt remaining after the closure of the bankruptcy.

   According to the previous article, the judge may grant remission for the debts of a bankrupt remaining after the closure of a bankruptcy pronounced pursuant to the law of 18 April 1851 on bankruptcies, bankruptcies and deferment of payments. This remission may not be granted to a bankrupt who has been convicted of simple or corrupt bankruptcy.

If the court considers that it would be possible to grant a remission, it must report on the debtor's professional and financial situation. And according to the law, this debt remission will be acquired within five years from the date of the judgment.
It is noted that articles 1675/13, paragraphs 3 and 4 of the Judicial Code contain three conditions that must be met:

- A justified proposal by the mediator.
- The insufficiency of the debtor's resources justifying the impossibility of concluding a judicial plan or an amicable plan.
- The agreement of the debtor.

Regarding the partial or total forgiveness of debts from criminal fines in favor of debtors,
Is the judge of the collective debt settlement allowed to decied a partial or total remission of criminal fines in favor of a debtor?

We have seen an exceptional decision by the Court of Cassation on November 18, 2013 in front of a decision on September 12, 2012 by the Court of Liège, Neufchâteau section. The Court ruled in application of article 1675 /13bis of the Judicial Code [29] that the total remission of debts, including the criminal convictions of the debtor, acquired within five years from the date of the ruling, except in the case of a return to better fortune and subject to compliance with various measures. These debts included criminal fines. The Public Prosecutor at the Court of Liège, for his part, brought an appeal in cassation against this ruling, alleging violation of article 110 of the Constitution [34], under which the King has the right to postpone or reduce sentences handed down by judges. Thus, according to him, this exclusive jurisdiction would prohibit the court from pronouncing a partial or total remission of criminal fines. The plaintiff in cassation added that in the event of non-payment of the fine, article 40 of the Criminal Code provides for the execution of a subsidiary imprisonment.

3. **Third type:**
   The prescription of debts:
   The law has put a mandatory rule in favor of debtors and in order not to always force them forever to pay their debts, the debtor can, after a certain period of time, be released from his debts. This extinction of debts is called (the extinctive prescription).
   In fact, extinctive prescription may be defined as a means of discharging the debtor's obligations after a limited period of time has passed and under the conditions determined by the legislator.
   On the legislator's side, the Belgian Court of Cassation admits that extinctive prescription does not affect the existence of the debt but only its eligibility and voluntary payment. And the prescribed debt does not give rise to a right to reimbursement. This means that the payment of a prescribed debt is not an undue payment [33, p. 22].
   We can therefore see that the judge is competent in matters of collective debt settlement to be able to say whether or not a debt is prescribed without being able to refer the case back to the materially competent judge.

2.5 THE MATHEMATICAL FORMULA FOR PAYMENT TO CREDITORS

The "formula 13" designed by Mr. Denis Maréchal [35] (President of the new Labor Court of Liège) to develop his judicial plans with total remission: a formula that is in line with the long term!
In order to determine the duration of the judicial plans including a remission of debt in principal, the Court of Liège has been applying, for several months, a calculation formula elaborated by one of its magistrates, Mr. Denis Maréchal. Already called "Maréchal grille" by some [36], its author more

correctly calls it "the formula 13" based on Article 1675/13 of the Judicial Code. This is an interesting initiative that cannot leave one indifferent.
This formula must be well understood as to its use.
We will therefore explain how it is used, the observations that led its author to adopt it and consider its possible advantages and disadvantages.

The judge fixes this duration between 3 and 5 years in application of article 1675/13 paragraph 2 of the Judicial Code [29]. It is appropriate to objectify the determination of the duration of a judicial plan.

The court empirically developed, tested and modelled a mathematical formula that it believes adequately meets the objectives pursued by the legislator, in a balanced way, based on two guiding principles:

- The greater the debt, the longer the duration of the judicial plan must be.
- The older the debtor, the shorter the duration of the judicial plan.

This formula is as follows:

$$\left(\frac{\sqrt{P}}{A} + 1\right) * 12 = \mathrm{D}$$

P = principal debt (passive).
A = age in years.
D = duration of the judicial plan in months.
The correction of "+1" was precisely integrated into the formula to limit the result in the most just proportions.
The number 12 means the 12 months in year.
After applying this formula, D will of course be minimum 36 months and maximum 60 months.
Numerical examples:

1. If Mr. X, aged 45, has a passive (debt) of 10,000 €, this gives:
$\left(\frac{\sqrt{10.000}}{45} + 1\right) * 12 = 38$ months.
2. If Mrs. Y, aged 32, has a passive (debt) of 22,000 €, this gives:
$\left(\frac{\sqrt{22.000}}{32} + 1\right) * 12 = 67$ months, reduced to 60 months (maximum 5 years).
3. If Mr. Z, aged 62, has a debt of 34,000 €, this gives:
$\left(\frac{\sqrt{34.000}}{62} + 1\right) * 12 = 47$ months.

How did this formula come about?

The author of this method started from the following observations:
- The maximum duration of five years being the general option.
- A five-year judicial plan may be all the more difficult to support certain requesters as their social and economic situation makes any prospect of improving their financial situation at the end of the procedure all the more impossible, and as their indebtedness is so high and their assets so low that repayment of the principal in full cannot be possible. In such cases, a five-year plan is no longer reasonable and the time frame of the judicial plan is systematically less than five years.
- For older debtors, the impact of this duration is even more discouraging and the risks of having the plan revoked or modified are also high so that repayment must be made quickly.
- Since the plan must aim at repayment of the debt, the importance of the debt must also be taken into account in determining a duration that meets the interests of all parties concerned.

The duration of the plan obtained by using this formula remains within the legal range of **3 to 5 years**. However, it may happen that the duration thus calculated is lower or higher than the legal points, in which case it will be reduced to these points.

How this formula is applied [37, p. 12]**?**

Once the duration of the plan is determined by this formula, the magistrate takes into account the economic situation of the requesters, the extra efforts they have made in the considered period and all the interests concerned, including those of the creditors, in order to determine the **available** amount to be allocated to them and the **available** amount to be left to these requesters to cover their current expenses.
The approach consists only of those **available** which are left to the "interactive debate" as provided for in Article 756 ter of the Judicial Code [38, p. 8] and to the free appreciation of the judge.
The plans fixed in the latest decisions taken on the bases of the "formula" can be summarized as follows:

duration in month (D)	Age (A)	Passive (debt) in Principal in euros (P)	Available monthly left to debtor in euros	Percentage of refund estimated from passive	deadlines at days between decision eligibility and judgment ordering the plan	Date of judgment
52	32	11.914	850	43%	475	05/10/09
60	64	77.933.62	1.350 [1]	11% [2]	432 [3]	14/12/09
36	48	4.904.96	1.100 [4]	88%	563 [5]	24/03/10
50	71	13.000	1.000	43%	875	02/11/09

For the formula to lead to plan durations longer than five years, it would be sufficient, for example, to replace "+ 1" in the formula with "+ 3" [33, p. 47].
[1] Available less than that provided for in the amicable plan and justified by the fact that the requester is going to try to find cheaper accommodation.
[2] Instead of 7.5% in the amicable plan.
[3] The judgment doesn't allow for a dividend on the reserve of 2,438.53 euros.
[4] Lower than that granted during the amicable phase, which unexpectedly resulted in a report of failure to act! The judgment explains in its reasoning that, "in this particular context, and taking into account the various interests involved, the court considers that a judicial plan should be imposed instead of restarting the amicable phase, which has come to nothing concrete after 17 months".
[5] The judgment does not provide for a dividend for creditors from the reserve of 2,438.53 euros.

2.5.1 Application of a mathematical formula

- **Current situation of the requester side**
  Mrs. P. is 48 years old and lives alone.
  She works as a domestic helper for 12 hours a week with the company S. and receives an unemployment supplement, for a total of +/- 1,274 EUR net per month.
  The total admitted passive (debt) amounted to EUR 4,904.96 in principal.
  The rent is 340 EUR per month.
  The company estimates her monthly charges at +/- 1,200 EUR.
  Recently, it was agreed to deduct 100 EUR per month from its income to be used to pay off its creditors.
  The requester side does not have any assets which can be realized concretely and reasonably, by reference to the concept of human dignity.
  Actually, the mediation account is credited with the sum of +/- 356 EUR.

- **Amicable settlement plan**
  No amicable plan could be developed, given the small amount of money made available since the beginning of the mediation.
  In this context, the mediator deposited a deficiency report.

- **Judicial Settlement Plan**
  Article 1675/3, paragraph 3, of the Judicial Code [29] says: "The purpose of the payment plan is to restore the debtor's financial situation, in particular by enabling him to pay his debts as far as possible and at the same time guaranteeing him and his family that they will be able to lead a life worthy of human dignity".
  The success of a collective debt settlement requires, when the over-indebted person's income is modest, that the creditors abandon their traditional patterns of reasoning.
  The question is no longer whether the payment to be made is "reasonable" for the creditor.
  This plan involves both a mathematical calculation and a reflection on the possibility for an individual and his/her family, living within a given social and economic context, to keep up a daily effort of austerity and budget management over a long period.
  In this particular context, and taking into account the various interests involved, the Tribunal considers that a judicial plan should be imposed rather than restarting the amicable plan, which has come to nothing concrete after 17 months.
  Therefore, the Tribunal considers that a judicial settlement plan referred to in Article 1675/13 is justified and must be established in accordance with the following modalities, which are included in the plan of the present decision.

  I. Duration of the Settlement Plan
  The judge sets this period between 3 and 5 years in terms of article 1675/13 paragraph 2 of the Judicial Code [29], using the mathematical formula.

  $(\frac{\sqrt{4{,}904.96}}{48} + 1) * 12 = 29$ months.

  Consequently, the Court considers that the duration of the plan should be set at 36 months, the legal minimum.

  II. A monthly mediation account (pécule)
  In application of Article 1675/13 paragraph 5 of the Judicial Code [29], the Court considers that the requester's pécule should be fixed at the sum of 1,100 EUR per month (including payment of rent).
  Mrs. P. should be required to make a greater effort, as the duration of the plan is kept to a minimum and the rent is low.
  Even if Mrs. P.'s situation is very delicate, the Court also notes that the amount of 1,100 EUR is well above the poverty line and is much higher than the minimum of the unsuitable income [39].

  III. Repayment of creditors
  An amount of EUR 120 per month will be used to repay creditors.
  The amount (+/- 50 EUR) will be used to set up a reserve to cover unexpected events and the costs of the mediation.
  An annual dividend will be distributed to the creditors.
  All other things remaining unchanged, an approximate sum of 120 EUR per month will therefore be used to repay the creditors for 36 months.

Together with the first dividend, compliance with this plan will, in principle, make it possible to repay approximately 88% of the total principal amount of the debts.

- **The costs of the debt mediator**
  The mediator submits a request for costs and taxation.
  The judicial plan includes a remission of total debts.
  The mediator requests that his cost report be charged to the Over-indebtedness fund.
  The current account of the mediation shows a balance of 356.89 EUR as at 10/03/2010.
  The mediator's expenses will be charged to the FTS [40].

The income debtor shall continue to pay to the mediator, in the manner communicated to him/her, until the due date or notified of a contrary decision.
The duration of the judicial settlement plan is set at 36 months, starting on 1/4/2010 and ending on 31/03/2013.
A pécule of 1,100 EUR will be granted to the debtor to face the needs of everyday life.
The surplus of its income (120 EUR per month) will be allocated to the repayment of debts and this **available** amount will be distributed to the creditors in proportion to the amount of the principal claims.

2.6 CONCLUSION

The Act of 5 July 1998, which provides for the collective settlement of debts through mediation under the supervision of the labor judge, plays an important role in raising awareness of the importance of making an amicable settlement or a judicial settlement plan by the judge and the mediator in order to achieve the repayment of creditors. However, the resources and expenses of the debtor must be permanently balanced in return.
The tool (formula 13) was developed, so the older the debtor is, the shorter the duration of the plan should be and vice versa.
If the tool makes sense, it also meets one of the legislator's objectives, which is to allow the over-indebted person to be integrated into the socio-economic system, as well as preserving the principle of human dignity.
The application of " formula 13" can be a useful tool to complement the legal provisions which, in the interests of efficiency and fairness, helps the judge to follow a certain objective course of action in a procedure that is often misunderstood and perceived as being particularly intrusive for applicants.
The benefit of our study is the importance of innovative and exciting new technology developments to facilitate digital justice.

Chapter 3

ARTIFICIAL INTELLIGENCE AND DEEP LEARNING

3.1 INTRODUCTION

Artificial Intelligence has been raptly developing to meet the growing expectations for people who want to be able to communicate with their devices. Artificial Intelligence has had a big boom since the 1950s and is being improved since then, thanks to many researches done in this field and more intelligent machines have been created. The goal of developing Artificial Intelligence is to create a computer that can make decisions and interact with people on its own. This is being achieved most often by giving the computer a training dataset that is big enough for the computer to be able to learn. For example, that a vehicle on a picture is a car or a bus. In contrast to conventional programming, the computer is not told that a picture has to be a car if certain criteria are being fulfilled, but instead only the information is given that a certain picture in the data set is a car or a bus and the computer has to figure out which criteria makes it a picture of a car or a bus.

As intelligent machines are getting more important in daily life, this chapter deals with definitions of Artificial Intelligence, Machine Learning and Deep Learning in particular, as well as the differences between these terms, as they are often being confused. The focus of this chapter is on Artificial Intelligence. Note that, although they rely on statistics and probability theories, Machine Learning and Deep Learning are to be understood as subfields of it.

Deep learning is one of the hottest tech topics right now. Large corporations and young start-ups alike are all gold-rushing this fancy field. If we think big data is important, then we should care about deep learning. Deep learning is the secret recipe behind many exciting developments and has made many of our wildest dreams and perhaps also nightmares come true. N,

3.2 THE DIFFERENCES BETWEEN AI, ML, AND DL

Roughly speaking, the graph below demonstrates the relationship between these 3 concepts. Deep learning is a subfield of Machine Learning and Machine Learning is a subfield of Artificial Intelligence.

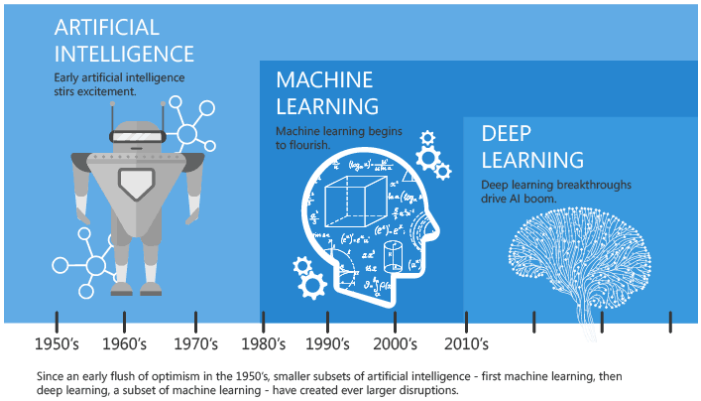


Figure 2: The classification of AI [41]

First, a short description of each word is listed below, so the differences can be discussed in more detail later on.

- *Artificial Intelligence (AI):* A set of techniques that enables machines to mimic human intelligence, or any rule-based application that simulates human intelligence by having the ability to predict, classify, learn, plan, reason and perceive.

- *Machine Learning (ML):* A subset of AI that incorporates math and statistics in order to allow the application to learn from data itself and improve with experience.

- *Deep Learning (DL):* A subset of ML that uses neural networks to learn from unstructured or unlabeled data, and to solve ever more complex challenges, such as image, audio, and video classification.

As can be seen in the listing above, Artificial Intelligence is a term for a computer that can copy human behavior. Machine Learning in the meantime covers the algorithms responsible for providing the computer to be able to learn. With these algorithms, patterns in human behavior can be indented. Decisions are then made based on the predictions the algorithm makes. The predictions will get better with every new data the algorithm can acquire [42]. Deep Learning algorithms work with unstructured data and can even solve complex problems by using a hierarchy of concepts. Meaning, it starts with a simple understanding and will progressively add to this picture until the whole picture emerges. This conveys that if the algorithm is exposed to different situations or patterns of data, it will adapt accordingly [43]. Deep Learning is based on neural networks and therefore requires a lot of processing power that did not exist ten years ago. Fortunately, it does now, which is the reason for the Artificial Intelligence thrive in the last decade. As Deep learning algorithms need a huge dataset to get trained and such datasets have not been available until around 2010, it was not used that frequently a while ago [42]. **Convolutional**, **Recurrent** and **Deep** neural networks are the three most common deep learning networks. Convolutional networks are used for data that has a grid-like topology. An example would be image or object recognition. Recurrent networks are used for sequential data, natural language data or cyclical data [43]. Deep neural networks use sophisticated mathematical modeling to process data in complex ways [44].

3.3 ARTIFICIAL NEURAL NETWORKS (ANN)

Artificial Neural Networks have been around since the 1940s, alas never worked efficiently. Although recently they have become one of the most popular machine learning models, after presenting results surpassing every other model by a high margin.

Neural Networks can tackle very efficiently massive datasets. This means that the neural network has enough data to create statistical models of the given data as input. What makes them even more

powerful, is the amount of new data coming out every year. As a consequence, they have been becoming more and more successful.

What is an Artificial Neural Network?
It is an information processing model that is inspired by the way biological nerve systems work, such as the brain [45]. In easier terms, it is a simple mathematical model of the brain which is used to process nonlinear relationships between inputs and outputs in parallel, like what a human brain does repeatedly.

3.3.1 What are Artificial Neural Networks used for?

ANNs are used for a variety of tasks, a popular use is for classification. For example, we can collect datasets of images of different breeds of cats and then train a neural network on the images. If we supply a new image of a cat, it will give a statistical score on how closely the new image matches the model and finally it will output what breed of the cat the image is. Neural Networks are also used in Self Driving cars, Character Recognition, Image Compression, Stock Market Prediction, Judgments Prediction and lots of other interesting applications.

3.3.2 Basic Structure of an ANN

The basic structure of an ANN consists of artificial *neurons* (similar to biological neurons in the human brain) that are grouped into *layers*. The most common ANN simple structure consists of an **input layer** (it is used to provide the input data or features to the network.), one **hidden layer** (it applies a series of functions to the input) and an **output layer** (which gives out the predictions)**.** In the following picture (Figure 3), a simple model of an artificial neuron network is shown. Each input neuron connects to all hidden neurons.

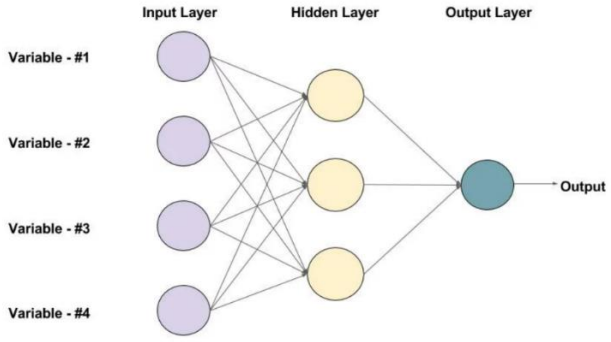


Figure 3: Basic structure of ANN [46]

3.3.3 Components of ANNs

- **Neurons**: An artificial neuron is the basic unit of a neural network.
- **Connections and weights**: The network consists of several connections, each connection provides the output of one neuron as an input to another neuron. Each connection is assigned a weight. A given neuron can have multiple inputs and output connections.
- **Activation function**: The activation function computes the input to a neuron from the outputs of its predecessor neurons and their connections as a weighted sum. A bias term can be added to the result of the propagation.

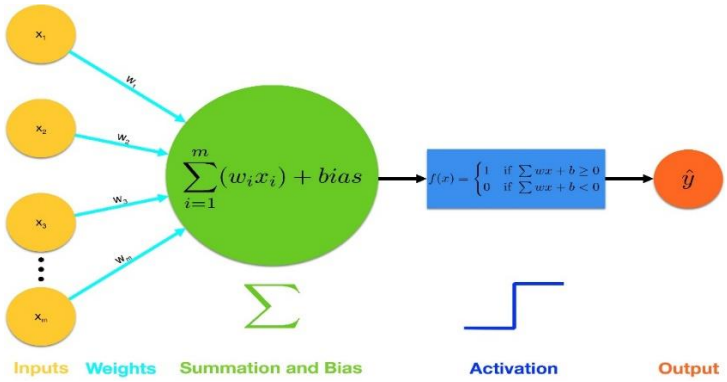


Figure 4: Components of ANN [47]

Every connection has a weight attached to it which may have either a positive or a negative value in associations. Positive weights activate the neuron while negative weights block it. Figure 4 shows a network structure with inputs (x_1, x_2,…x_m) being connected to a neuron with weights (w_1, w_2,…w_m) on each connection. The neuron sums all the signals it receives, whit weights are multiplied to each input and then add bias- The bias value allows the activation function to be shifted to the left or right, to better fit the data [48]-. This output (y) is then passed through an activation function, which can be linear or nonlinear. The activation function in Figure 4 is a *step* but the most commonly used function is the *sigmoid* because of its easily differentiable properties. There are others functions like hyperbolic tangent (*tanh*), rectifier (*relu*) and more.

3.3.4 Training Methods for Artificial Neural Networks (ANN's)

- Supervised learning [49]

  In supervised training, both the inputs and the outputs are provided. The network then processes the inputs and compares its resulting outputs against the desired outputs. Errors are then propagated back through the system, causing the system to adjust the weights which control the network. This process occurs over and over as the weights are continually tweaked. The set of data which enables the training is called the training set. During the training of a network, the same set of data is processed many times as the connection weights are ever refined.

- Unsupervised learning [49]

  In unsupervised training, the network is provided with inputs but not with desired outputs. The system itself must then decide what features it will use to group the input data. This is often referred to as self-organization or adaption.

An example of training ANN: The dataset can be labelled and it comes with an "answer sheet", telling the computer what the right answer is, like which emails are spam and which are not, this is called **supervised learning**. Other datasets might not be labeled, and we need to tell the algorithm to associate or cluster patterns that it finds without any answer sheet, this is called **unsupervised learning**.

3.3.5 How Does a Neural Network Learn?

Information flows through a neural network in two different ways. When the model is learning (being trained) or operating normally (either being used or tested). Patterns of information from the dataset are being fed into the network via the input neurons, they trigger the layers of hidden neurons, and these in turn arrive at the output neurons. This is called a **Feedforward** network.
Each neuron receives inputs from the neurons to its left, and the inputs are multiplied by the weights. Every neuron adds up all the inputs it receives and if the sum is more than a certain threshold value, the neuron "fires" and triggers the neurons it's connected to (the neurons on its right).

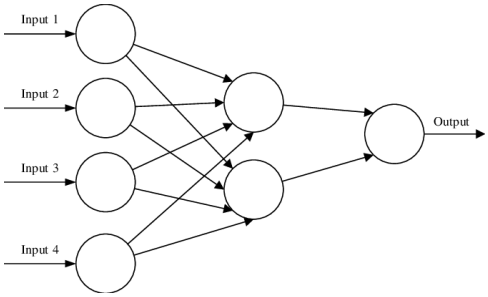


Figure 5: A simple feedforward neural network (FNN), composed of an input layer, a hidden layer and an output layer. This structure is the basis of a number of common ANN architectures [50].

For an artificial neural network to learn, it has to learn what wrong and right it has done. This is called **Feedback**. Feedback is how we learn what is wrong and right and this is also what an artificial neural network needs to learn. There are several types of feedback architecture, which has feedback connections from the output layer to the input layer or from the hidden layer to the input layer. In other words, a feedback architecture distinguishes itself from a *feedforward* architecture, in that it has at least one feedback link. A recurrent NN is shown in the Figure 6 below, which has a feedback connection.

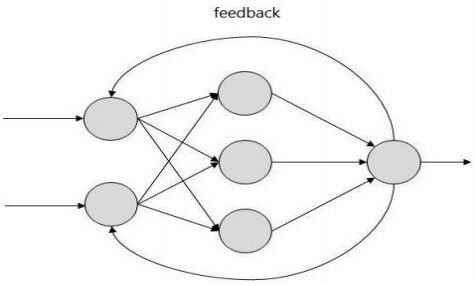


Figure 6: Feedback learning [51]

Neural networks learn things in exactly the same way as the brain, typically by **Competitive Learning**. It is a combination of both *feedforward* and *feedback* ANNs [52]. It compares the output of the network with the output it was meant to produce and uses the difference between the outputs to modify the weights of the connections between the neurons in the network. It works from the output layer through the hidden neurons to the input layer going backward. Over time, back-propagation causes the network to learn by making the gap between the output and the intended output smaller to the point where the two match exactly, so the neural network learns the correct output.

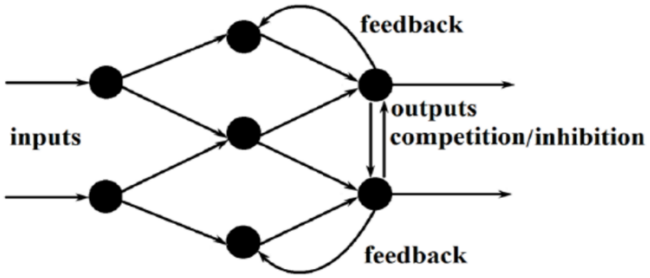


Figure 7: Structure of a competitive neural network between outputs [53]

3.4 ACTIVATION FUNCTIONS

What is an Activation Function?

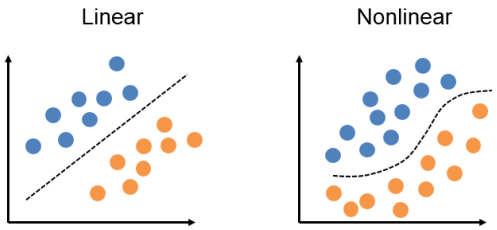
Biological neural networks have inspired the development of artificial neural networks. Activation functions introduce nonlinear properties to neural networks. It is attached to each neuron in the network. Their main purpose is to convert an input signal of a neuron in ANN to an output signal. The activation function does the **nonlinear** transformation to the input making it capable to learn and perform more complex tasks such as images, video, audio, and data sets.

In ANN we do the sum of products of inputs (X) and their corresponding Weights (W) and add the bias, then apply an activation function f(x) to it to get the output of that neuron then decides whether it should be "fired" or not and feed it as an input to the next neuron.
So consider the following neuron: $Y=\sum(X * W) + bias$, the value of Y can be anything ranging from -inf to +inf. The neuron really doesn't know the bounds of the value. So, by adding an activation function for this purpose to check the Y value produced by a neuron and decide whether outside connections should consider this neuron as fired or not. In other words, it determines whether the neuron should be activated (fired) or not. Activation functions also help normalize the output of each neuron to a range between 1 and 0 or between -1 and 1.

3.4.1 Types of Activation Functions

- **Linear Activation Function** is the combination of each inputs with their weights ($x_1*w_1 + x_2*w_2 + ...x_m*w_m$), it doesn't help with the complexity of various parameters of usual data that is fed to the neural networks.
- **Non-Linear Activation Functions** are the most used activation functions. It makes it easy for the mode to generalize or adapt with a variety of data and to differentiate between the outputs. The Nonlinear Functions are mainly divided on the basis of their range or curves [47].

Figure 8: linear and non-linear diagram [54]



"Activation functions cannot be linear because neural networks with a linear activation function are effective only one layer deep, regardless of how complex their architecture is. Input to networks is usually linear transformation (input * weight), but the real world and problems are nonlinear. To make the incoming data nonlinear, we use a nonlinear function. An activation function makes a decision that determines the presence of a particular neural feature between 0 and 1, where zero means the absence of the feature, while one means it is present. A neural network must be able to take any input from -infinity to +infinite, but it should be able to map it to an output that ranges between {0,1} or between {-1,1} in some cases thus the need for activation function. Non-linearity is needed in activation functions because its aim in a neural network is to produce a nonlinear decision boundary via non-linear combinations of the weight and inputs" [55] -user7479.

The most popular types of non-linear Activation functions:

- **Step**

  This activation function "f(y)" is very basic and it comes to mind every time if we try to bound output. It is basically a threshold base classifier, in this, we decide some threshold value to decide output "y" that neuron should be fired or not [56].

  f(y) = 1 if y > 0 else 0 if y < 0.

- **Sigmoid or Logistic**

Its form is f(y) = 1 / (1 + exp (-x)). Its Range is between 0 and 1. It is a S — shaped curve. It is easy to understand and apply but it has major reasons which have made it fall out of popularity:

- Vanishing gradient problem, which occurs because we convert large input in the range between 0 and 1, therefore, their derivatives become much smaller which doesn't give a satisfactory output. To solve this problem another activation function such as ReLu is used where we do not have a small derivative problem [56].
- The output isn't zero centered. It makes the gradient updates go too far in different directions. 0 < output < 1, and it makes optimization harder.
- Computationally expensive, the exp() function is computationally expensive compared with the other non-linear activation functions.

- **Tanh — Hyperbolic tangent**

  Its equation is: f(y) = 1 - exp(-2x) / 1 + exp(-2x) or 2 * sigmoid(2x) – 1.
  Its range is: between -1 and 1, it is similar to the Sigmoid function. So, it also suffers vanishing gradient problem, but:
  - Output is zero centered (-1 < output < 1), which makes it easier to model inputs that have strongly negative, neutral, and strongly positive values [57].
  - Optimization is easier.

- **ReLu -Rectified linear units**

  Its form is: f(y) = max (0, x), this means that when the input x < 0 the output is 0 and if x > 0 the output is x. Its Range is: (0 to infinity). ReLU is the most widely used activation function right now.
  It is computationally efficient. ReLu is nonlinear function that allows the network to converge very quickly. Although it looks like a linear function, ReLU has a derivative function and allows for back-propagation. Due to its functionality, it does not activate all the neurons at the same time.
  When inputs approach zero, or negative values, the gradient of the function becomes zero. The network cannot perform back-propagation and cannot learn, neither it can map nor fit into data properly which creates a problem (The Dying ReLU problem) [58].

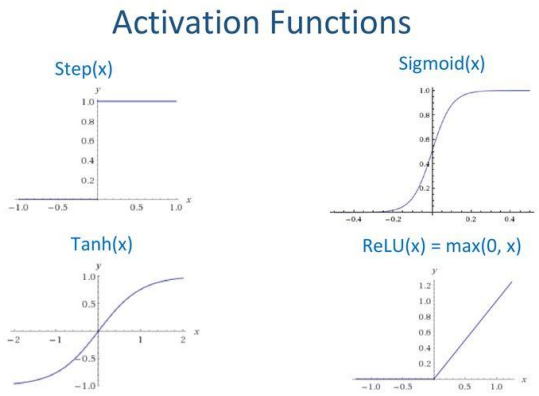


Figure 9: Types of Activation functions [59, p. 9]

3.4.2 Derivatives or Gradients of Activation Functions

The derivative, also known as a gradient, of an activation function, is extremely important for training the neural network. This gradient is calculated, using back-propagation. Common problem that may

occur during the training process of an artificial neural network is vanishing gradient. Specifically, this problem involves weights in earlier layers of the network. In the worst case, this may completely stop the neural network from further training. During training the neural network, the back-propagation works to calculate the gradient with respect to weights. The gradient with respect to weights in earlier layers becomes very small, like vanishingly small. Then, vanishing gradient. Vanishing gradient is most concerned with earlier weights and is caused by multiplying values against each other, which are less than one when calculating the gradient.

Neural networks are trained using a process called *back-propagation*. This is an algorithm which traces back from the output of the model, through the different neurons. They were involved in generating that output, back to the original weight applied to each neuron. Back-propagation suggests an optimal weight for each neuron, which results in the most accurate prediction. In Artificial neural networks the weights are updated using Back-propagation method.

3.4.3 Which one of the Activation Functions can we use?

As we have seen different categories of activation functions, we need to know which activation function has to be used in some situations.
Based on the properties of the problem we might be able to make a better choice for easy and quicker convergence of the network.
Sigmoid functions generally work better in the case of classification problems.
Sigmoid and Tanh functions should not be used nowadays due to the Vanishing Gradient Problem which causes a lot of problems to train, degrades the accuracy and performance of a Deep Neural Network Model [57]. Nowadays, the optimal activation function for a certain neural network is ReLu which should only be applied to the hidden layers. If we don't know the nature of the function we are trying to learn, then maybe we should start with ReLu, and then work backwards. ReLu works most of the time as a general approximator [56].

3.5 ARTIFICIAL NEURAL NETWORK VS. DEEP NEURAL NETWORK

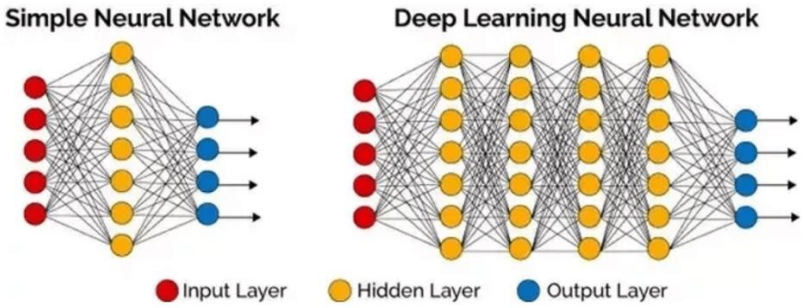


Figure 10: ANN vs. DNN [60]

Artificial Neural Networks (ANN) are composed of a large number of simple elements, called **neurons**, each of them makes simple decisions. Together, the neurons can provide accurate answers to some complex problems, such as natural language processing, computer vision, and AI.
A neural network can be "simple", meaning it has an input layer, one hidden layer that processes the inputs, and an output layer that provides the final output of the model. A Deep Neural Network (DNN) commonly has between 2-8 additional layers of neurons. Research from Goodfellow, Bengio and Courville [61] and other experts suggests that neural networks increase in accuracy with the number of hidden layers.
The ANN with one hidden layer is called Simple Neural Network and more than one hidden layer is named Deep Neural Network (DNN).

The hidden layer performs mathematical operations on the input layer. One of the most difficult challenges in creating a neural network is determining the number of hidden layers, rather than the number of neurons in a single layer.
The ANN is not a creative system, but DNN is much more complicated than the first one.
The neural network can get one result (a word, an action, a number, or a solution), while the deep neural network solves the problem more globally. It can draw conclusions or predictions depending on the information supplied and the desired result. The neural network requires a specific input of data and algorithms of solutions, whereas the deep neural network can solve a problem without a significant amount of marked data [62].

3.6 CONCLUSION

Artificial neural networks are one of the promises for the future in computing. They offer the ability to perform tasks outside the scope of traditional processors. They can recognize patterns within large data sets and then generalize those patterns into recommended courses of action.
The design of neural networks does require a skill. It also requires "art." This art involves the understanding of the various network topologies, current hardware, current software tools, the application to be solved, and a strategy to acquire the necessary data to train the network. This art further involves the selection of learning rules, activation functions and how to connect the neurons within the network. Then, the art of neural networking requires very much hard work, as data is fed into the system, performances are monitored and rules modified. Until the network achieves the desired results.
Neural networks can now deny credit cards, monitoring systems, predict justice, predict the debt repayment period and inspect the work. Yet, the future holds even more promises. In my opinion neural networks will become the leading edge in an age of "intelligent" machines.
We have seen all the necessary details to explore Artificial Neural Networks, its structure, how to learn, types of training and the different categories of activation functions.
In chapter 5, I will try to cover each and every concept and practical implementation in as much detail as possible through a study case of settlement of collective debts.

Chapter 4

DECISION MAKING ASSISTANT FOR THE JUDGE

4.1 INTRODUCTION

This chapter aims at developing a decision support system to let the judge understand the impact of his decisions. As explained in section 2.3, in case of not accepting or lacking a mediator to make an **amicable plan.** The **judicial plan** is the only solution to settle the debts. I propose a software in this chapter to help the judge make such a judicial plan. It takes the form of a website.

This website doesn't reduce to the sole calculation of formula 13. It can process different aspects of the Database: introduce debtors, creditors, statistical data and it shows the different repayment curves. The major requirements of this website are introduced in the next section.

I have made a tutorial video explaining in detail the steps for using Decision Making Assistant. Here is the link: https://github.com/UNamurCSFaculty/memoire-dania-otri/blob/master/Decision%20Making%20Assistant-%20Dania%20Otri.mp4

4.2 WEBSITE OVERVIEW

4.2.1 Requirements Analysis

This section provides the main requirements of the website. The goal is to help the judge to make a decision. The website depends on the calculated variables and shows the impact of his decision making, referred to by a monthly amount that should be paid to the creditors. Like the interfaces that I have proposed, this website aims to develop a decision support tool for the judge. Each interface is a tab for each aspect. The main interface presents the description of the person concerned (debtor). It also includes ‘details’ to move to the following tabs. The tabs are: a tap for Income, Expenses, Debts and finally a tab for Simulations. Each tab has an important function. The judge needs to know the coordinates of the debtor, the source of his money and where he spends them (income and expenses). This helps the judge to predict the monthly amount. The judge also needs to know how many creditors that the debtor has and the information about the amounts (debt). Then the judge can simulate the situation of each debtor and make his decision after witnessing the impact of changing the duration to repay the debt.

The following section details how the website fulfils those requirements.
The judge who will use this website is an aware person used to work with a personal computer for administrative or office tasks, or able to use the software in its field of activity. The website enables us to:

- The main interface is to insert a debtor’s information. In the table below, all submitted debtors are listed within. Every record is accessible and removable.

- **Income tab**: is where we insert the debtor's monthly income, i.e. his salary and all other investments. The tab shows all registered incomes in a table, which in turn is removable.
  For the people who are at the CPAS, the amounts of their social integration income can be found online [63].
  For Family allowances, the amount can be found online [64].
- **Expenses tab**: Insert the debtor's expenses and reveal all the expenses in a table. The tab first begins with a field named *expenses*, which defines the nature of expense. The next two fields (*Start*, *End*) present the timeline of the expense. The *requested amount field* is where the expense amount is registered. The *average rate field* is the carefully considered amount by the Belgian government. For example, the average rent, electricity bills, etc. The judge takes care about these statistics numbers to make better decisions. The *predicted amount field* is a predicted amount set by the judge.
- **Debt tab**: is where we list the creditors by name, total debt, and paid debt. The *rest amount field* is auto-calculated. The name of the creditor is inserted in the *creditor name field*. The *total amount field* is the initial debt. The *paid amount field* is what the debtor has already paid (there must be a small amount paid as a guarantee). The *rest amount field* is the total debt minus the paid amount.
- **Simulation tab**: there are two sub tabs: Information tab is to manipulate the numbers and Creditors Repayment tab is to manipulate the duration.
  - Information tab (as shown in Figure 11):
    Left side: On the top, calculate and show the *Rest Debt* (sum of rest amount in Debt tab). Next is *monthly available* (sum of monthly amount in Income tab - sum of predicted amount in Expenses tab). This field represents the **available** for the debtor to repay his debt. The judge will consider the amount that should be taken from this available. If the monthly available is negative that means the predicted amount should be less. Finally *Maréchal formula 13* (defined in p.24) is a formula applied from the court of Liège and it calculates the duration without limitation. The Law of Belgium limits the duration between 36-60 months.
    Right side: First on the top is *monthly repayment* should be considered by the judge because this amount will be repaid to the creditors. Then the *proposed duration* is inserted by the judge. In the end, *total repayment* is the monthly repayment * proposed duration (auto-calculate) and it represents the total amount of repayment debt. This amount should be equal to *Rest Debt* amount.
  - Creditors Repayment tab:
    Shows a table with information and it is able to simulate each record of the table.
    Total Amount label: is the rest amount of creditor1 (C1) in the Debt tab.
    Repaid Amount label: is (the rest amount of C1 / sum of the rest in Debt tab) * total repayment in the Information tab.
    Rest label: total amount – repaid amount. It reminds the judge about the rest amount that should be repaid.
    When a judge selects a record from the table, a graph appears: axe of **x** is the proposed duration, and axe of **y** is the repaid amount, as shown in Figure 12 and Figure 13.

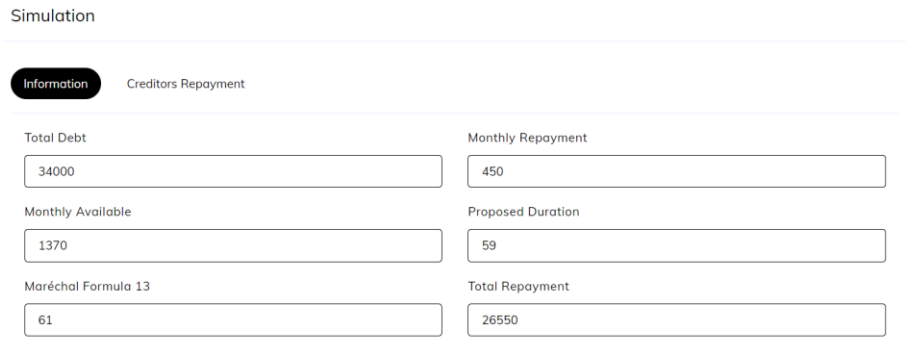


Figure 11: Simulation tab includes the Information tab

The auto-calculation in the *information* tab enables us to gain time and move fast through the application.

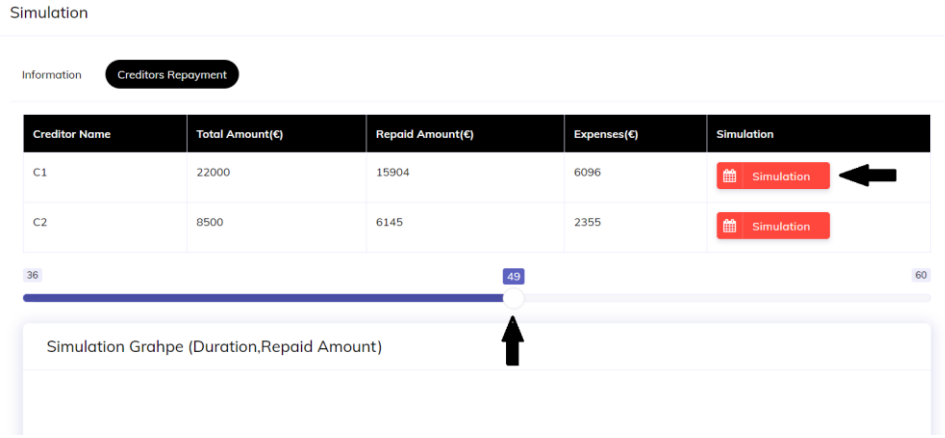


Figure 12: Creditors Repayment tab

We can simulate one record at a time by pressing the *simulation* button, and we can slide the bar to change the duration to be less or more and witness what impact this change brings.
The style of the graph is a straight curve between two points and they are duration and repaid amount.

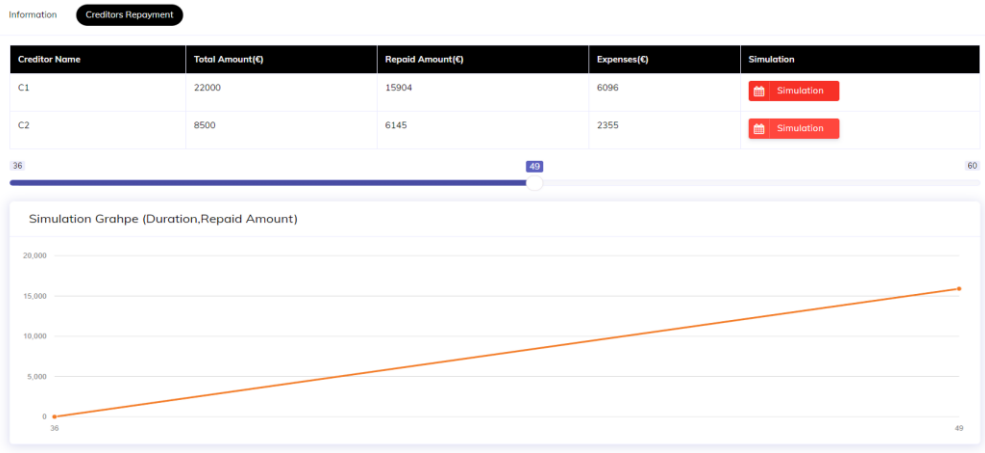


Figure 13: time bar for the duration

The website allows the judge to change the duration in the duration time bar. Once it's changed, all the calculations that depend on the duration will change. From here, the judge can realize the impact of his decision easily. Once the time bar changes we can re-press the *simulation* button to see the updates of the graph.

For more information about the *Average Rate* field in the **Expenses tab**, the average household budget is documented and then acknowledged by the judge. Through this document, the judge can select the minimum wage needed [65].

4.2.2 Website Technology

This website is the work product of web development. We can access the Website through a Web browser, using an internet connection.
There are two fundamental divisions of web development: front-end development (also called client-side development) and back-end development (also called server-side development).

Front-end development refers to constructing what a user sees when he loads a website, the content, design, and how he interacts with it. This is done with three codes HTML, CSS, and JavaScript.

HTML stands for Hyper Text Markup Language. It is the standard markup language for Web pages. Every web page on the net is written in HTML. HTML elements are represented by <> tags.
CSS short for Cascading Style Sheets is a code for setting style rules for the appearance of web pages. CSS handles the cosmetic side of the web. It describes how HTML elements are to be displayed.
Finally, JavaScript is a scripting language that's widely used to add functionality and interactivity to web pages. It can calculate, manipulate, and validate data.

Back-end development controls what goes on behind the scenes of a website. A back-end often uses a database to generate the front-end. The back end of a website consists of a server, an application, and a database. In order to make the server, application, and database communicate with each other, the back-end use many different languages and frameworks like PHP, Node.js, etc… to build an application, and tools like MySQL, Oracle, etc… to find, save, or change data and serve it back to the user in front-end code.

PHP and Node.js are both powerful back-ends for dynamic websites. PHP is the most known and commonly used language for server-side scripting. The PHP language sets up a simple connection to the SQL database and has no hosting confinements. On the other hand, Node.js is significantly complicated. PHP works quite well with MySQL database. As compared to Node.js, PHP is supported by many hosting services [66]. This makes the implementation and integration of PHP easier and more sufficient than Node.js. The MVC (Model-View-Controller) architecture in PHP framework helps the code to be used and maintained. It aids in the separation of a file for each module separately. PHP is also completely stable as compared to several programming languages [67]. All the mentioned points made me choose PHP as the main language for this project.

I also chose MySQL for Database management system (DBMS). DBMS is a Collection of programs that helps the user to create and maintain a database. SQL stands for Structured Query Language and it is one of the most popular open source relational database systems. It allows us to create many databases and access them via the web. It is familiar between web application programmers for its common association with the PHP programming language, and it can be installed on many operating systems such as Windows, Linux or Mac.
MySQL is the perfect choice for emerging or medium businesses due to its ease of handling and low operating costs compared to other options. But Oracle is a multi-model database with a single, integrated back-end. This means that it can support multiple data models like document, graph, relational, and key-value within the database, and it is better to use for big businesses enterprises.
What makes MySQL special are:

- **Speed:** Speed is the time to execute a query and return results to the inquirer, which is very important for the success of any database system. MySQL has achieved high results in this regard with better performance than its competitors.
- **Security**: When dealing with a multi-user database, security is the pillar. The developers of MySQL have taken this area with tremendous care to ensure that MySQL is as secure as

possible. MySQL is accompanied by a complex system of access control and a privileged system to prevent unauthorized users from accessing the database.

- **Scalability** and **portability**: MySQL can deal with a huge complex database without losing much of its performance, and even when the tables are filled with data, it can be transferred from one platform to another without any problem.
- **Ease of use** and **not difficult to learn**: MySQL is not a programming language, it's a query language. It provides anyone with basic English language knowledge to get interesting data from the database and can easily write SQL queries.

Now it becomes easier to create and manage a MySQL database with phpMyAdmin. phpMyAdmin is one of the most popular applications for MySQL database management. It is a free and open source tool written in PHP. Through this software, we can do the commands, import and export MySQL database tables easily.

Frameworks are libraries of server-side programming languages that construct the back-end structure of a website. CodeIgniter is a PHP Model-View-Controller (MVC) framework used for developing web applications rapidly. CodeIgniter provides out of the box libraries for connecting to the database and performing various operations like sending emails, uploading files, managing sessions, etc.

Figure 14 represents how the architecture of the website is built and shows which technologies are used for Front-end and Back-end development. It explains the information mentioned in the previous paragraphs.

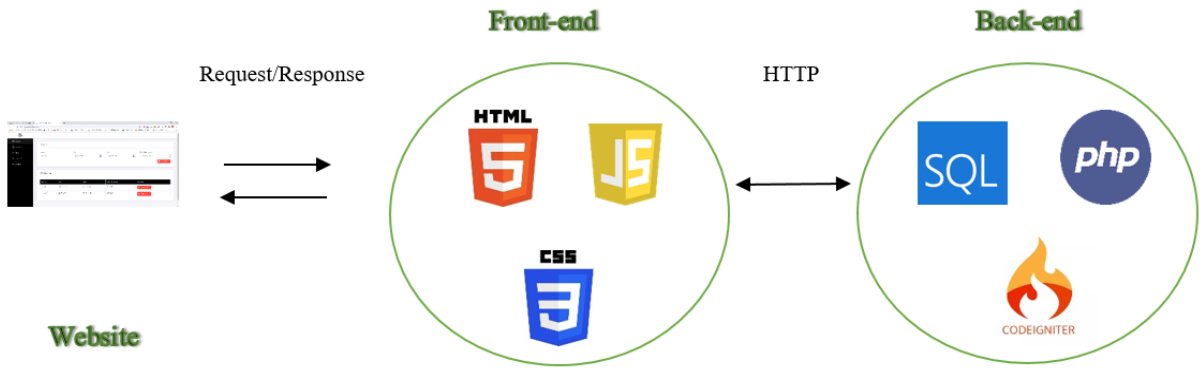


Figure 14: schematic of Front and Back end development

A browser is a website application that enables a user to communicate with the Front-end. It sends out HTTP requests to render a page visible to the user. While rendering a page, some codes are executed inside the browser. HTML, CSS and JavaScript are the parts of the front-end in their final form. Front-end is intended to be used directly by the browser. The back-end can assemble an HTML response. It prepares the data to transmit back to the browser. The parts of Back-end are not directly visible to the user. Back-end runs on a server and it never runs on the user's device. There are HTTP requests and responses involved between Front and Back-end. It simplifies the communication between them. HTTP stands for Hyper Text Transfer Protocol. HTTP Request / Response circle is:

- The browser sends an HTTP request to the web.
- A web server receives the request.
- The server runs an application to process the request.
- The server returns an HTTP response to the browser.
- The browser receives the response and shows it to the client.

4.2.3 Project Design Pattern and Framework

This Website is written in HTML, CSS, and JavaScript. The used framework is CodeIgniter, CodeIgniter –as defined–is PHP MVC (Model, View, and Controller).
PHP frameworks organize the development of web applications written in PHP through providing a basic structure to build the web applications and prevent monotonous and repetitive coding, which saves the time and helps build more stable applications by ensuring proper database interaction and coding on the presentation layer. The general idea behind the mechanism of a PHP framework is referred to as Model View Controller (MVC).
PHP MVC is an architectural design pattern that separates an application into three main logical components: Model, View, and Controller. Model refers to data, View refers to the presentation layer and Controller to the application or business logic. Each architecture component is built to handle specific development aspects of an application. This is important because when other developers look back at the code they can see how it was written, which in turn makes it easier to debug and work with. It was traditionally used for desktop graphical user interfaces (GUIs). Nowadays, the MVC architecture has become popular for designing web applications. PHP MVC makes coding in PHP faster and less complicated, and it simplifies working with complex technologies by hiding all the complex implementation details and providing standard methods that we can use to build our application.
Here are more details about the components of MVC:

- **Model** is concerned with all the data-related logic that the user works with. It can be used to perform data validations, process data and store it. The data can come from a database, XML document or any other valid data sources. This can either represent the data that is being transferred between the View and Controller components or any other business logic-related data. In our model, there are 4 files (4 pages), each class file is corresponded to each table in the database (add data, update, and delete record in table).
- **View** is used for all the user interface (UI) logic of the application, and it deals with presenting the data to the user. This is usually in HTML pages. It ultimately demonstrates how the model is displayed on screen. Most of the objects in the view are buttons, sliders and text, in other words, view is the website design. In our view file there are 5 views and each view represents an interface of our website.
- **Controller** acts as an interface between model and view components to process all the business logic and incoming requests, manipulate data using the Model component and interact with the Views to give the final output. The controller mediates between the model and view. In our project there are 5 class files, each class is corresponding to each page. Controller structure can be customized, that means it can have a different structure by developer. For users comfortable and good understanding about code, I write them as 5 files that are corresponded to each view page. The controller links the models and views together depending on the requested resources.

A good example to clarify the MVC framework is: the car has the windscreens (view) which the driver (controller) uses to monitor traffic ahead then speed or brake (model) depending on what he sees ahead.

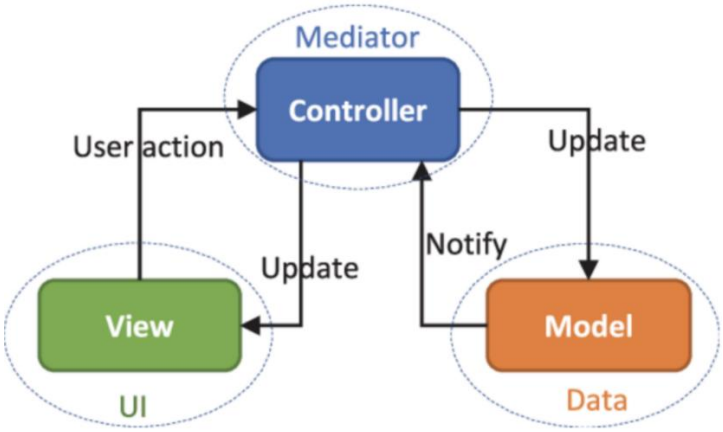


Figure 15: MVC design pattern diagram [68].

PHP MVC has many types of framework. Selecting the best PHP framework is a challenge on how to benefit the most from the advantages of MVC. Here are some of the popular PHP frameworks: CakePHP, Kohana, Zend and CodeIgniter. The last one is the most popular PHP MVC frameworks. It is known for its ease-of-use, performance, lightweight, and speed. It has a rich set of libraries that help build websites and applications and it offers simple solutions. This framework is ideal for new developers on PHP frameworks. Here are some of its key features: fast even with database tasks, well-documented, and built-in features and components.

4.2.4 Database Design

There are 4 tables in the database: Debtor table, Income table, Balance (Expenses) table, and Debt table. Each table represents a tab of our website and each table contains the same information on the website's tabs. As defined in the previous paragraph, model file has 4 tables. In Simulation tab is the resulting demonstration page, considering that it doesn't need a table in the database. The associations between Debtor and other tables are 1 to 0..* (* means many). This database simplifies the content of the website interfaces.

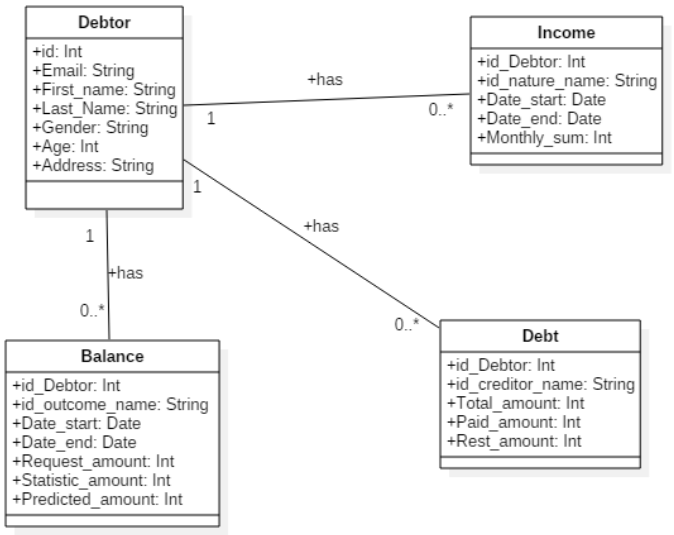


Figure 16: UML Diagram of Database Design

4.2.5 Website Architecture

HTLM, CSS, and JS are used to write the Front-end, as mentioned before in section **4.2.2**. The more these languages progress and improve (JavaScript in specific) the more processing can be made on the

client-side rather than on the server-side. Which leads to a better Front-end. It supports having classic interfaces as multi-pages application. The MVC is an MPA (multi-page application) [69].

MPA is a traditional design pattern. It uses traditional programming languages such as PHP, .NET, and Java. MPAs run on a server and can communicate directly with databases. This approach is suitable for designing simple applications, but if the application becomes more involved in a complex interface, it can cause performance issues.

With MPA, the entire page is refreshed when we request information, where each interaction receives request-wait-response-wait processing, and the page is fully reloaded with each click. The same back-end code cannot be used to develop the mobile app with MPA. Which means it may have to start all over again.

MPAs are a classic approach to application development, whenever the application needs to display data or send data back to the server, it has to request a new page and every time the content changes, which is then rendered in the web browser. Generating pages on a server, uploading them to the client and rendering them in the browser takes little time. But this kind of problem can be solved by using java script to increase speed and reduce load.

The multi-page design pattern is a preferred option for large companies that have large product portfolios, for instance eBay and Amazon.

MPAs allow for better information architecture. We can create as many pages as needed, and we can include as much information on a page as needed without any limits. The navigation is clear so that the user can easily find their way around the website which has a positive impact on their experience.

I chose this architecture style because it provides the judge with a simple interface, achieving the basic requirements. No need for complex interfaces or extremely dynamic behaviour.

4.3 CODE OVERVIEW

This section gives examples of the programming codes for each language that we used to do this website.

- Starting with creating a table in a database with MySQL. For instants the table of debtor:

```
CREATE TABLE IF NOT EXISTS `debtor` (
`id` int(100) NOT NULL,
  `email` text NOT NULL,
  `first` text NOT NULL,
  `last` text NOT NULL,
  `gender` text NOT NULL,
  `age` int(100) NOT NULL,
  `address` text NOT NULL
) ENGINE=InnoDB DEFAULT CHARSET=utf8 AUTO_INCREMENT=1 ;
```

Let's examine the syntax in detail.

First, we specify the name of the table that we want to create after the CREATE TABLE keywords. The IF NOT EXISTS is optional. It allows us to check if the table that we created already exists in the database. If yes, MySQL will ignore the whole statement and will not create any new table.

Second, we specify a list of columns of the table, columns are separated by commas. Each column has a specific data type (INT, TEXT, CHAR), optional size (INT (100), VARCHAR (255)), and constraints. For example: The NOT NULL constraint ensures that the column will not contain NULL.

Third, we can optionally specify the storage engine for the table in the ENGINE clause. We can use any storage engine such as InnoDB and MyISAM.

I put in the group of columns these instructions:
The CHARSET= utf8 is a special set of characters, MySQL supports various character sets that allow us to store almost every character in a string. The default character set is (latin1).
The AUTO_INCREMENT indicates that the value of the column is incremented by one automatically.

- Using a PHP language to make the template, design and functions of the website. A PHP script starts with `<?php` and ends with `?>`. The default file extension for PHP files is ".php".

A PHP script can be placed anywhere in the document. A PHP file can contain HTML tags, and some PHP and Java scripting code and surly CSS for the designing. Note that PHP is a server-side scripting language, while JavaScript is a client-side scripting language.
If PHP is like a paint-brush to paint a picture, then JavaScript is a paint-color.

An example below of a simple PHP file, with a PHP script that uses a PHP function "echo" to output the text "Hello World!" using HTML tags on a web page:

```
<!DOCTYPE html>
<html>
<body>
<h1>My first PHP page</h1>
<?php
echo "Hello World!";
?>
</body>
</html>
```

All HTML documents must start with a `<!DOCTYPE html>` declaration to inform a web browser that the document being rendered is an HTML document and is compliant with HTML standards, while the declaration is not an HTML tag.
The `<html>` tag represents the root of an HTML document. Every HTML element is defined by a start tag, some content, and an end tag: `<html>..</html>`.
The `<body>` tag defines the document's body and it contains all the contents of an HTML document, such as headings, paragraphs, images, hyperlinks, tables, lists, etc.
The `echo` statement can output one or more strings. In general, it can display anything that can be displayed to the browser, such as strings, numbers, variables values, the results of expressions etc.
To create a function in PHP, a function declaration starts with the word `function`:

```
<?php
function writeMsg() {
  echo "Hello world!";
}
writeMsg();  // call the function
?>
```

In the example above, we create a function named `writeMsg()`.The function outputs `"Hello world!"`. To call the function, just write its name followed by brackets `{ }`.

- Using MVC design pattern for PHP language to separate the code into 3 parts and that makes it easy to understand and to edit.

Creating Our Model: next we are going to create our model that will extend from CI_Model. The CI_Model is part of the CodeIgniter libraries. The model will be located in application/models/home name_model.php.

```
<?php
class Debtor_model extends CI_Model
{
 public function add_debtor($debtor)
    {
        $this->email = $debtor['email'];
        $this->first = $debtor['first'];
        $this->last = $debtor['last'];
        $this->gender = $debtor['gender'];
        $this->age = $debtor['age'];
        $this->address = $debtor['address'];

        $this->db->insert('debtor', $this);
        return $this->db->insert_id();
    }
}
?>
```

This function is for adding a new debtor, including his email, first name, last name, gender, age, and address. Then insert them to the database to this debtor.

Creating our view: the view is a web page representing the interface to the user. The view will be located in application/views/pages name_view.php.

```
<!DOCTYPE html>
<html lang="en">
<head>
    <title>Debtor</title>
</head>
<body>
<div>
     <label for="email">Email</label>
     <input type="email"  placeholder="Email">
</div>
<div>
     <label for="first_name">First Name</label>
     <input type="text"  placeholder="First Name">
</div>
.
.
</body>
</html>
```

In the example above, the `lang` attribute is used to identify the language of text content on the web. This information helps search engines return language specific results, a declaration of `<html lang="en">` tells the browser that all content on the page is English.

There are many divisions in the `body` tag that divide the element and make them very organized.

Creating our controller: we will use the default CodeIgniter controller located in application/controllers/welcome.php.

```
<?php
```

```
if (!defined('BASEPATH'))  exit('No direct script access allowed');
class Welcome extends CI_Controller {
public function index() {
            $this->load->view('welcome_message');
      }
}
?>
```

Here, `(!defined('BASEPATH'))` ensures that users do not directly access the controller class. Our controller extends from `CI_Controller` class. The `function index()` is the function that maps to index.php. It uses CodeIgniter's input class to load a particular view.
Views are never called directly, they must be loaded by a controller. In a MVC framework, the Controller acts as a traffic cop, so it is responsible for fetching a particular view.

Now, to test the application, it should have the source code on the computer. Install the XAMMP softer. Which is a free web server. Once the XAMMP is installed, put the source code on the 'htdocs' folder of XAMMP. Move to the XAMMP control panel to start the Appach and the MySQL. Type the link http://localhost/judge/ and see the interfaces.

This website took almost two months to build and almost about a hundred or so, lines of coding.

4.4 WEBSITE EVALUATION

Taking from the course IHM (interaction human-machine) [INFOM216], I have evaluated the website with different qualified users. First, I interviewed, individually, 3 users. 2 from my family and a friend. The interviews were accompanied by taking notes, recoding their voice and observing the attitudes of the interviewees. I asked the interviewee a group of questions to analyse and collect the data. These interviews lasted around 15 minutes each.

Here are the questions numbered:

1. What do you expect to see when I say a website of decision making assistant for the judge?
2. What do you think about the debtor information interface?
3. Now, after going to 'details' for that debtor, what can you think about Income tab?
4. Ok, what do you think about Expenses tab? Do you find this helpful?
5. Here is the Debt tab, what can you see in this tab?
6. Do you find these previous tabs useful? What do you think about the functionalities?
7. Now, let's discover the simulation tab. What do you realize? Let's fill these fields.
8. Move to creditors repayment tab, what can you understand? Do you find the table useful?
9. Move the time bar. What do you see? Do you find it a good tool? What about the graph?
10. Do you think these functionalities are helpful to know the impact on making the decision?
11. How can you move to the next debtor?
12. And on a scale of 1 to 10 how much would you rate the ease of use of the website?
13. Okay, what about the design and colors of the interfaces?

After interviewing the 3 users and on the basis of notes taken, the various interviews were copied faithfully as follows:

Here are the answers of a judicial user who knows how to use a computer:

1. I expect to see a website with interfaces that display important information for the judge and help him to make his decision.
2. This interface for inserting the debtor information, and here is a table of an old and new debtor. But can this application traits a group of debtors or just one at the time? Me: No, this application settles debts for one debtor.

3. Income tab, let the judge knows all the incomes for this debtor. That helps him to know how much amount to leave to the debtor to have a dignified life.
4. Expenses tab is useful too for having an idea about what the debtor needs to pay.
5. This tab for collecting information about the creditors, but why this total rest in the bottom of the page? Me: that helps for the calculation later in the simulation tab, just to have an idea about it.
6. Yes, they are clear to me.
7. Okay, that's good and saves time, the right side I will fill them with….
8. Oh yes, that's quite good, I can see all the calculations needed are done. If I press the simulation button what can happen? Me: try it. Oh good this is a graph with time.
9. Let me move it to…, ok I see that is wonderful. Now I can see the impact of moving this bar and it helps me to know how much amount I should leave to the debtor to repay his debt.
10. Yes of course, I agree. I can know the duration requested to repay the debt but how much should I pay for each creditor. Me: this is another future request but this app focuses on the duration. I think there are privileged creditors and non-privileged creditors in the Belgian law.
11. I think from the 'back to debtors' tab.
12. Between 7-8.
13. It is good and visible.

Here are the answers of a non-judicial user and educator:

1. I expect this website to be accurate but is it safe to let a non-human judge's assistance deal with human lives? Me: This website will be double-checked by the tribunal court and the judge will make the final decision.
2. The interface is simple which is good and presents a clear window of information.
3. The income interface seems really flexible and easy to use. Why do we have a start and end date in the tab? Me: because every income has a beginning and end that make the website more specific.
4. The Expenses tab is detailed yet keeps the simple design which makes it very practical. But why doesn't the average rate field show a list of each article's value? Isn't it more convenient? Me: exactly, it could be a future option to add.
5. In the Debt tab, I can see everything a man needs about the debt and its owners.
6. I think these tabs can be used and tested easily after I tested it, it shows big promise.
7. Well I guess, it is practical but what is the formula 13? Me: This formula calculates the duration in months. It was invented by a Liège court judge to help give an initial thought over the expected duration.
8. The creditors repayment tab gave me a negative expenses making me realize that there is some room to make the payment less. I believe this tab to be very constructive.
9. The time bar is a very smart way to make the range of decision bigger which in turn gives the judge a fine space to decide. I find the simulation tab very important for presenting the collected information clearly.
10. Definitely.
11. I pressed the 'back to debtors' tab which brings me back to the main page with all the debtors' information, including the one I tested. This transition between interfaces helps not to confuse one debtor with another.
12. I give it a complete 10.
13. Simple is best.

Here are the answer of a non-judicial user and computer scientist:

1. I expect to see a website where I can have choices and possibilities to change the parameters.

2. When I see a website, I first think it can be accessible to anyone from anywhere. This information is too sensitive and it should not be public. Me: Yes, you are totally right, the website could be on a local server. The judge is the only person who will see this information. The judge is a reliable and responsible person. He/she will save and deal with this information, but to be more secure, I will make an account for each judge with a password. Exactly, a home page where a judge can login. The usability and accessibility concepts are important to consider for any software programming. In All Debtors table, I see the remove and edit button. The latter is important to save time and minimize effort rather than remove the record and re-insert it.
3. It is understandable.
4. It is clear and all the labels express the content of the fields.
5. It is ok.
6. As I see, the judge will predict the monthly available amount of a debtor. This amount will be paid to creditors. So the previous interfaces are useful to collect the needed information.
7. It helps to see the combination of values. When the judge proposes a duration, the value changes.
8. The table clarifies all the amounts of debt, repaid and the expenses. Yes, it is a global view.
9. I prefer to have an option to simulate a group of creditors. Me: this option can be a new update to do.
   The time bar is a real simulation. I like it.
10. Yes, it is useful.
11. By pressing 'Back to debtors'.
12. I give it 6/10.
13. The design is nice.

After taking these comments into consideration, now we can think about what should be changed in the website functionalities. These changes could be done in the future work.

4.5 CONCLUSION

This section introduces a software to help the judge to make the decision. It takes the form of a website about collective settlement of debts. First, a review of the requirements, the information of the debtor, and his debt has been detailed. Second, this information and more have been collected and processed into a database. Finally the website reveals both information and results in organized tabs and pages.

The website was implemented by using HTML, CSS, JavaScript, and multi-Pages Application. PHP and MySQL have been used to render our project requirements in a better way.

A good development approach separates the data from the presentation and encourages the use of a single entry point into an application and all they are done with MVC.

We have used CodeIgniter. It is an easy to learn and use PHP MVC framework that can greatly reduce the time spent developing applications.

The website was tested by different users, which provides many hints on extensions that could be implemented in the future.

Chapter 5

A NEURAL NETWORK TO PREDICT THE DECISION

5.1 INTRODUCTION

I trained and developed a neural network to give with accuracy an acceptable duration, which is the most suitable timeline to repay the debt completely. It's important to make the program simple and precise, so any judge would use it with utmost efficiency and the debtor would get the best chance to settle the debt. I also made it to replace the judge's decision for predicting the duration.
This Debt Repayment Predictor is a deep neural network, which is simple. Why is it simple? Because it consists of no more than two hidden layers. Other deep neural networks consist of more than two. The hidden layers will do the mathematic calculation and apply the perfect algorithm to give us a satisfied result.

This section explains how we employed artificial intelligence to be a part of this project and how it can be useful to replace a Judge or help him to take his decision.

I have attached a video link that I have made to explicitly demonstrating the functionality of Debt Repayment Predictor: https://github.com/UNamurCSFaculty/memoire-dania-otri/blob/master/Debt%20Repayment%20Predictor-%20Dania%20Otri.mp4

5.2 NEURAL NETWORK OVERVIEW

5.2.1 Requirements Analysis

Debt Repayment Predictor is a simple Deep Neural Network. It is constructed to predict the duration for repaying the debt. We give the neural network 3 different inputs. These inputs are the debtor's age, total debt and monthly available amount. The NN analyses the inputs and matches them with the stored dataset. This operation is called training. We improve the neural network training with 3 different types of activation functions: Sigmoid, Tanh and Relu [as defined in paragraph 3.4.1]. We compare between these activation functions to know which has the perfect accuracy. We will use the best activation function to test a new set of data. This procedure helps us to have a neural network with the most effective activation function to predict a suitable output.

5.2.2 Dataset Format

The key to get a better neural network is training. To have a good training result one must have a good (massive) dataset. The dataset in my project is represented by records of numbers (age, debt, amount and duration).
I faced a problem on how to find a good and big dataset to train the neural network. The settlement collective of debts is a new project to be digitalized. There were only 4 examples [as defined in

paragraph 2.5]. It is critically small to feed a NN, so I generated 50 records limited by a range based on the formula 13. The dataset was created as an excel file. Before feeding the neural network, the dataset was standardized. We standardized the data to make sure that it is internally consistent. Standardized data is fundamental for precise data analysis. Standardization comes when the dataset has large differences between its ranges. The table below shows an example of the dataset. The dataset contains 3 inputs (Age, Total Debt, Monthly Available Amount), and one target (Duration).

Age	Total Debt in euros	Monthly Available Amount left to debtor in euros	Duration in month
32	11.914	850	52
64	77.933.62	1.350	60
48	4.904.96	1.100	36
71	13.000	1.000	50

The dataset is stored as a *CSV* file, to be used due to the activation of code. **CSV** stands for Comma Separated Values. It is a plain text file that contains a list of data separated by commas. It is designed to easily export and import data into other programs or applications. The CSV file is readable and is easily viewed with a text editor like Notepad. It helps to better arrange and organize large amounts of data. Here's an example of an European CSV file, where the decimal separator is a comma and the value separator is a semicolon:

```
Year;Make;Model;Length
1997;Ford;E350;2,35
```

5.2.3 Project Architecture and Implementation

Since many of tools for data analysis and Neural Networks are written in Python, I decided to use Python for this project due to the number of libraries available for data manipulation. Overall, the language is easy to use and it doesn't take much time to code a solution in Python. Also, it has a great number of free data science, machine learning and data analysis libraries such as Scikit-Learn.

Scikit-Learn is a set of simple and efficient tools for data analysis. The framework is built on top of several popular Python packages, namely NumPy, SciPy, and matplotlib [70]. NumPy stands for Numerical Python. It is the core library for scientific computing in Python. The NumPy module allows us to read *csv* files.

I used Python 3 8.3 and the framework scikit-learn-0.23. Also, I used the platform Anaconda. It is a free and open source distribution of Python programing language [71] and it makes Python easy to install. It aims to provide everything about data science packages "out of the box".

This project is a non-linear regression, using a multi-layer Neural Network (deep neural network). So I used the MLPRegressor of scikit-learn for this purpose. MLPRegressor stands for "Multi-Layer Perceptron" Regression. It is a multilayer feedforward neural network training system that implements MLPRegression algorithm to solve an MLPRegression Task. MLP consists of many layers and each layer is fully connected to the following one. The neurons of the layers are using nonlinear activation functions. I have imported the regressor from the following library:

```
from sklearn.neural_network import MLPRegressor
```

- **Regressor Components:**
  - One input layer with 3 neurons. They receive input from a dataset. Each neuron is connected with another neuron from the next layer. Each connection has a particular

weight. We have assigned the weights randomly depending on the regressor. When all the neuron values from the input layer are multiplied, it generates a value for the first hidden layer.

- Two hidden layers with 10 neurons respectively. These layers are between input and output layers. They are called hidden layers because they are not visible to the external environment. The main calculation of a neural network is done in the hidden layers. The hidden layers have a defined activation function that determine if this neural will be activated or not. They perform the necessary calculation on all the inputs from the input layer and generate a result. Choosing the number of hidden layers and the number of neurons of each hidden layer is an important part of our neural network architecture. Two hidden layers are good for a simple dataset. They can represent an arbitrary decision to arbitrary accuracy with rational activation functions and can approximate any smooth mapping to any accuracy [72]. Since the model is simple, I expected that 10 neurons per hidden layer would be sufficient. This is indeed the case as we shall see on page 60.
- One output layer with 1 neuron. The result from hidden layer is forwarded to the output layer. The output layer receives the values from the last hidden layer.

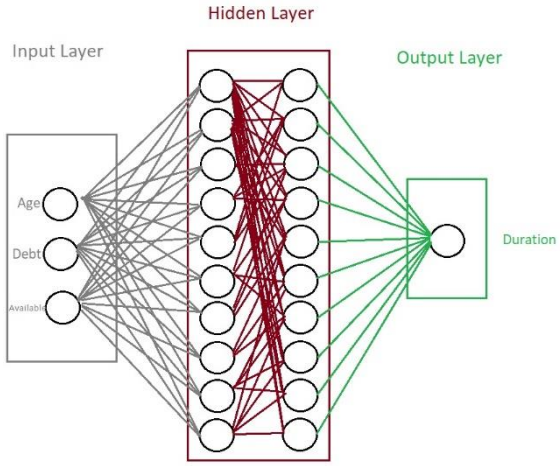


Figure 17: Regressor Components

As mentioned in [5.2.2 Dataset Format] the age, total debt and monthly available amount of the debtor will be the 3 neurons of the input layer. The duration for repaying the debt will be the result of the output layer.

- **Training and testing the regressor:**
  The following code shows the creatino of MLPRegressor:

```
regressor = MLPRegressor
        (
        hidden_layer_sizes=(10, 10),
        activation=MyActivation,
        solver='lbfgs',
        random_state=35,
        max_iter=300
        )
regressor.fit(X_train, Y_train)
```

- The parameter ‘hidden layer sizes’ represents the number of neurons in each hidden layer. We have 2 hidden layers and 10 neurons each.

- The parameter (activation) represents the activation function. I pass to this parameter a variable 'MyActivation'. This variable represents 3 different activation functions, one at a time. I created three regressors. Each one has a different activation function. These activation functions are logistic, tanh and relu. The logistic sigmoid function, returns f(x) = 1 / (1 + exp(-x)) and it limits the output between 0 and 1. The hyperbolic tangent function, returns f(x) = tanh(x) and it limits the output between -1 and 1. The rectified linear unit function, returns f(x) = max (0, x) and it will give the input directly if it is positive, otherwise, zero.
- The parameter 'solver' is for weight optimization. I use the algorithm LBFGS as a solver. I will explain more in the next paragraph.
- The parameter random state determines random number generation for weights and bias initialization. It will guarantee the same sequence of random numbers each time we run the code. Using an integer value will produce the same results across different calls.
- The parameter 'max iter' is the maximum number of iterations. The solver iterates until this number of iterations. Its value is 300 epochs that the model get trained on.

After crating the regressor, we fit the dataset. The method 'fit (*x*, *y*)' prepares the model to fit the arrays *x* and *y*. Parameter *x* is the input data and parameter *y* is the target values or the output data. The method returns a trained MLP model.

- **Solver (L-BFGS):** Stands for Limited-memory Broyden–Fletcher–Goldfarb–Shanno. It's a mathematical algorithm for nonlinear optimization. This optimizer belongs to Quasi-Newton family of methods. The goal of LBFGS is to minimize the value of a differentiable scalar function *f*.
  Scikit library offers two other solvers, they are **sgd** and **adam**. sgd stands for stochastic gradient descent. It is a linear model. It works with data represented as dense numpy arrays of floating values. adam refers to a stochastic gradient-based optimizer. adam works very well on relatively large dataset in terms of both training time and validation score. For small dataset, lbfgs can converge faster and perform better. I have chosen this solver because it is the most famous and it adapts to small datasets.
  L-BFGS is an iterative method for solving unconstrained, non-linear optimization problems. It starts with an initial guess of the optimal value, and proceeds iteratively to refine that guess with a sequence of better values. The approximation of the Hessian or its inverse is dense, storage and computing requirements grow at least the double number of parameters.
  For this reason the method cannot be applied directly to large-scale optimization problems. Rather than storing the Hessian matrix, it approximates the second derivative matrix and updates with gradient evaluations then stores only the last few updates, so it saves memory [73]. L-BFGS uses the approximated second order gradient information which provides a faster convergence toward the minimum. The derivatives of *f* are used to identify the direction of the steepest (gradient) descent, and also to form an estimate of the Hessian matrix (second derivative of *f*). Therefore I used this solver because it's ideal for small data size. Otherwise, there are optimizers such as `adam` and `sgd` which are better for the case of big dataset size, but not good for small dataset size. The accuracy score of lbfgs is 0.970.

The Hessian Matrix is a square matrix of second derivatives of a scalar function. It describes the local curvature of a function of many variables.

The algorithm L-BFGS handles simple constraints of the form:

$$l_i \leq x_i \leq u_i$$

Where *li* and *ui* are per-variable constant lower and upper bounds, respectively for each *xi*.
Consider now:

$$f : \mathbb{R}^n \rightarrow \mathbb{R}$$

A function that is convex twice continuously differentiable and a nonlinear, whose gradient at point x_k is denoted by $g(x_k)$ for the purpose of simplicity. L-BFGS starts with an initial guess for x in order to minimize the function $f(x)$. It generates a sequence of better approximate solutions for x until a termination criteria is achieved.
The iteration (sequence) of L-BFGS is:

$$x_{k+1} = x_k + \alpha_k p_k$$

Where x_k is the current point and x_{k+1} is the new point. P_k is the step direction and α_k is the step length. The step direction Pk can be calculated by the approximation of the inverse of the Hessian matrix. The step length α_k is selected to comply with the Wolfe Condition. The Wolfe Condition is a set of disparity for performing inexact line search, especially in quasi-Newton methods. More information available on [74].
L-BFGS continuously updates the approximation of the Hessian matrix in each iteration (n x n matrix) based on the current Sk and Yk values, because calculating the Hessian matrix in each iteration is too expensive to compute. Where Sk is the position difference and Yk is the gradient difference in the iteration. These vectors have the same length as vector x.

$$s_k = x_{k+1} - x_k$$

$$y_k = \Delta f_{k+1} - \Delta f_k$$

Instead of storing and updating a fully dense of the Hessian n x n approximation, L-BFGS algorithm stores last m iterations ($m \prec n$) and uses them to build operations requiring the Hessian. The recent iterations m have the likely curvature information. So the earlier iterations have a less likely curvature information and they are not related to the Hessian behaviour. For this reason, they are rejected in favour of the memory.
The sk and yk pairs are stored from the last m iteration. The L-BFGS stores $2 \times m \times n$ compared to $n \times n$ storage. The L-BFGS uses two-loop recursion algorithm to calculate the step direction pk. In Figure 18 and Figure 19, I respectively show the L-BFGS algorithm and its two-loop recursion:

Algorithm 1 L-BFGS

1: **procedure** L-BFGS
2: Choose starting point x_0, and integer $m > 0$
3: $k \leftarrow 0$
4: **while** true **do**
5: Calculate $\Delta f(x_k)$ at the current point x_k
6: Calculate p_k using Algorithm 2
7: Calculate α_k where it satisfies Wolfe conditions
8: $x_{k+1} \leftarrow x_k + \alpha_k p_k$
9: **if** $k > m$ **then**
10: Discard the vector pair $\{S_{k-m}, y_{k-m}\}$ from storage
11: **end if**
12: Compute and Save $s_k = x_{k+1} - x_k$ and $y_k = \Delta f_{k+1} - \Delta f_k$
13: $k \leftarrow k + 1$
14: **end while**
15: **end procedure**

Figure 18: L-BFGS Algorithm 1 [75]

Algorithm 2 L-BFGS two-loop recursion

$p \leftarrow -\Delta f(x_k)$
for $i = k-1, k-2, ..., k-m$ **do**
  $\alpha_i \leftarrow s_i \cdot p / s_i \cdot y_i$
  $p \leftarrow p - \alpha_i y_i$
end for
$p \leftarrow (s_{k-1} \cdot y_{k-1} / y_{k-1} \cdot y_{k-1}) p$
for $i = k-m, k-m+1, ..., k-1$ **do**
  $\beta \leftarrow y_i \cdot p / s_i \cdot y_i$
  $p \leftarrow p + (\alpha_i - B) s_i$
end for
return p

Figure 19: L-BFGS Algorithm 2 [75]

Where x_0 is the initial point, k is a variable, p is the inverse of second gratin of matrix Hessian, after that we store only the last pair of Sk and Yk and β is the value of calculation that will be later used in the calculation of p.
The cost of per iteration in L-BFGS is $O(nm)$, storage is $O(nm)$.

5.3.4 Result Explained

In this section, we are going to see which activation function has the best score, then define it to be the main activation function in the neural network. This opens the door to a good predicted result.

I've trained 3 neural networks with 3 different activation functions, then evaluated their score and elapsed time duration. Here is the results table:

Activation Function	Score	Elapsed Time(ms)
Sigmoid	95.592	0.1316
Tanh	98.139	0.1555
Relu	86.292	0.1825

The score is the accuracy calculated for the test dataset.
The elapsed time means the actual time taken for a neural network compiled with a given activation function. It took to be trained around 300 epochs and to be evaluated for test data. We calculated it using the `time` model of Python. Here is how to import the time in Python:

```
import Time
```

As seen in the table above, the score for Tanh is better and the elapsed time for `sigmoid` is the smallest. Tanh can be the best activation function for this model. When we use the tanh as the activation function in the hidden layers, we get a piecewise non-linear regressor and smooth shape. As well as, its values are between -1 to 1, so the mean for the hidden layer comes out be 0 or very close to it, this helps in centring the data by bringing mean close to 0. This makes learning for the next layer much easier.

- **Output result**

```
[[43, 25213, 500]]  ->  [57.29596923]
```

The result array represents the printed input values (left) and the printed output value (right).
Inputs are: Age= 43, Total Debt= 25213, Monthly Available Amount= 500.
Output is 57 months.
The output value indicates that the duration to repay the debts is 57 months. This value is predicted by the DNN. I find this result is reasonable compared to the application of formula 13.
Let's test new values by editing the Python code.

```
x = [[27, 30000, 600]]
y = reg2.predict(normalize_data(x))

print(x, " -> ", y)
```

The result is:

```
[[57, 30000, 650]]  ->  [49.57882613]
```

The predicted output is 49 months, which is compatible with the dataset as well as with formula 13 (which produces 48 monthes).

5.3 CODE OVERVIEW

There are 3 main functions that have led this project and achieved the required prediction of the duration. Each function has a specific task to do. First of all, the function 'prepare data' is to prepare the dataset by splitting and standardizing it to be ready as an input of neural network. Secondly, the function 'train_eval_neural_network' aims at building, training and testing a neural network, as well as calculates the accuracy.
Finally, the function 'normalize data' aims at preparing and normalizing the new set of data to be a new input of neural network.
We are going to explain in detail these functions in the code of neural network with Python.

```
def prepare_data(input_data, target_data):
    X_train, X_test, Y_train, Y_test = train_test_split
    (
        input_data,
        target_data,
        test_size=0.3,
        random_state=35
    )
    # standardization
    scaler = StandardScaler()
    scaler.fit(X_train)
    X_train_scaled = scaler.transform(X_train)
    X_test_scaled = scaler.transform(X_test)

    return X_train_scaled, X_test_scaled, Y_train, Y_test
```

The function: `def prepare_data (input data, target data).`
In this function, we split the dataset between train and test sets and stander them. The function takes a loaded dataset as input and target values then returns the dataset split into two subsets for input and two subsets for output.
Typically, the separation of dataset helps to ensure that the testing and training sets are similar. We can minimize the effects of data discrepancies to better understand the characteristics of the model. It is easy to determine if the model's guesses are correct. Train set: Is used to fit the model on available data with known inputs and outputs. Test set: Is used to evaluate the fitting model performance.

The goal is to estimate the performance of the model on new data where we do not have the expected output with the highest accuracy. To split the dataset we used the library:
`from sklearn.model_selection import train_test_split`, it splits arrays into random train and test subsets. The parameter `test_size=0.3`, could be float or integer. The float value represents the ration of the dataset to include in the test split and it should be between 0.0 and 1.0. The 0.3 value means 30% of dataset is assigned as a test set and the 70% of dataset well assign automatically to the train set. I have tested to see if there are any differences in results by changing the ratio value. So, I reach to this value to be the test size. The reason to choose this value is, the neural network will predict the target well. The parameter `random_state=35`, controls the shuffling applied to the data before applying the split. A random_state parameter may be provided to control the random number generator used. It achieves precision and evaluates on the same subsets of the dataset. Using an integer value will produce the same results across different calls (call the function).

For the standardization of data, we used the library:
`from sklearn.preprocessing import StandardScaler`.
Scale generally means to change the range of values. Standardization is part of a Scikit-learn algorithm and it is a scaling technique where the values are centred on the mean with a unit standard deviation. Standardization refers to shifting the distribution of each column/variable/ features to have a mean of zero and a standard deviation of one.
The StandardScaler supposes the data is normally distributed within each feature and will scale them where the distribution is centred on 0, with a standard deviation of 1. Standardization of a dataset is a common requirement for many neural networks estimators and it is important when we compare measurements that have different units. For example, a variable that ranges between 0 and 1000 will outweigh a variable that ranges between 0 and 1. Using dataset without standardization will give the variable with the larger range weight in the analysis. Transforming the data to similar scales can prevent this problem. The core method of standardize data is the following:

Standardization:

$$z = \frac{x - \mu}{\sigma}$$

with mean:

$$\mu = \frac{1}{N}\sum_{i=1}^{N}(x_i)$$

and standard deviation

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Figure 20: Standardization Formula [76]

Where *Z*= standard score, *X*: the observation value, μ is the mean of the training samples, and σ is the standard deviation of the training samples. Standardizing a dataset includes rescaling the distribution of values. It means each column will have the mean of observed values which is 0 and the standard deviation is 1.
The `scaler.fit(X_train)` method is used to compute the mean and standard deviation to be used for later scaling. The `scaler.transform(X_train)` method uses a previously computed mean and standard deviation to auto scale the data. It also performs standardization by centring and scaling.
Finally, the function returns a list containing train-test splits of inputs.

```
def train_eval_neural_network(dataset, MyActivation):
    start_time = time.time()
    X_train, X_test, Y_train, Y_test = dataset
    regressor = MLPRegressor
    (
        hidden_layer_sizes=(10, 10),
        activation=MyActivation,
        solver='lbfgs',
        random_state=35,
        max_iter=300
    )
    regressor.fit(X_train, Y_train)
    score = regressor.score(X_test, Y_test)
    end_time = time.time()
    duration = end_time - start_time
    print("Score for " + MyActivation + " : " + str(score * 100) + ", elapsed time(ms): " + str(duration))
    print("\t")
    return regressor
```

The function `def train_eval_neural_network(dataset, MyActivation)` is used to build a neural network using the regressor (a tearm is used to predict the target) MLPRegressor and tanning it. The function calculates the accuracy of the trained regressor with the method `regressor.score(X_test, Y_test)`. It automates the prediction of data using X_test and compares it with Y_test. In the Scikit-Learn package, MLPRegressor is implemented in neural network module. I have imported other modules like “train_test_split” to split the dataset into training and testing sets to test the model. I also utilized “StandardScaler” to scale the data as different features have wide value range scale. It is very important to scale the data used for training the model. The elapsed time was calculated by saving the attributes ‘start time’ and ‘end time’ from building to training the regressor using the method `time.time()`. The regressor was trained for sigmoid, hyperbolic and RELU activation functions. But the MLPRegressor supports the “sigmoid” and “hyperbolic tan” functions. The function returns the model with all calculated times.

```
XY = np.loadtxt("new.csv", delimiter=";")
X, Y = XY[:, :-1], XY[:, -1]
dataset = prepare_data(X, Y)
```

After these functions, we load the dataset using the method `XY =np.loadtxt("new.csv", delimiter=";")`. This method imports the csv file into a matrix using NumPy. It assumes no header row and all data has the same format. The library NumPy in particular knows how to read and interpret CSV files. I have separated the matrix of dataset into `X, Y = XY[:, :-1], XY[:, -1]`, which means X for input and Y for target. The form of matrix is XY [row index, column index]. The matrix [:, :-1] means, we keep all the rows and all the columns without the last column. The matrix [:, -1] means, we keep all the rows and the last column only. Then both of X and Y matrixes are passed to `prepare_data` function.

```
reg1 = train_eval_neural_network(dataset, 'logistic')
reg2 = train_eval_neural_network(dataset, 'tanh')
reg3 = train_eval_neural_network(dataset, 'relu')
```

We train the regressor with the prepared dataset and 3 different activation functions.

```
def normalize_data(x):
    X_train = train_test_split(X, Y, test_size=0.3, random_state=35)[0]
    scaler = StandardScaler()
    scaler.fit(X_train)
    x = scaler.transform(x)

    return x
```

The function `def normalize_data(x)` is to normalize/standardize the new data input, this new data will be tested by the regressor that is trained with the "Tanh" activation function. From all activation function, Tanh has the best accuracy.

```
y = reg2.predict(normalize_data(x))
```

Ending this section with the method `predict(normalize_data(x))`, it predicts the label of a new set of data. This method accepts one argument X (like an array or matrix) and returns an array of target values per element in X.

The whole code takes 79 lines including the comments and one month to be done.

5.4 PROGRAM EVALUATION

I have conducted a small evaluation for the neural network with two interviewees that have varied experiences. I have walked through the program with each individually. We have compared the results of the neural network and formula 13. I asked the interviewee some questions for feedback. Each interview took about 10 minutes.

Here are the particular questions in the following order:

1. Do you understand what the program produces? Do you find it easy to use?
2. After you have experienced the Debt Repayment Predictor and formula 13, which one do you prefer and why?
3. Which one of the two methods do you find more reasonable?
4. Do you believe the neural network can replace the judge?

I have delivered the answers faithfully. Here are the first interview's answers:

1. Yes, I have a good overview of the program and it produces the duration in which the debtor should repay his debt. I find it a bit complicated but with proper guidance, it will be easy.
2. If I have to choose, I would rather debt repayment predictor, because it has a limited duration.
3. I find the neural network is more reasonable for several reasons, one of which it allows the debtor to finish his debt before retirement.
4. Yes and No. Yes, it can replace the human judge in most cases but it could fail in some cases. This is where the human judge presence is needed. Me: In which cases could the neural network fail? Since the neural network predict based on pervious court decisions, it must have a range of success. No matter how high the range is, there's still a chance for the program to fail.

The second interview's answers:

1. Yes, I understand that the program gives a duration. If I've learned how to write commends, it would be easy to use.
2. I will go for the debt repayment predictor. It is certainly developed to be better than the formula 13. It also doesn't need to bring the calculator to calculate the duration.

3. Of course the result of neural network is more reasonable, because the program predicts the durations fitting the law of Belgium. However the formula gives such a result without considering the law.
4. The world is changing. Who knows maybe the robots lead us. The speed and availability of the robot judge are a huge advantage to the justice office and the law. Especially nowadays, in the pandemic period.

I've made this program to prove that a well-trained neural network could replace a human judge. These two feedbacks have accounted for the difficult use but the quick in prediction. They do nothing to contradict my concept but rather prove that it could be applicable in the future.

5.5 CONCLUSION

In this chapter, I have used a neural network to give an acceptable duration with accuracy.
The neural network is a type of Deep Neural Network. It has been coded with python language, the library scikit and the solver LBFGS. It produces a reasonable and good result.
I have worked with a small amount of handmade dataset which is challenging. It is an impossible task without doing a review on tribunal information and analysing them. These analyses open the door for us to gain some vision of the manipulated data.
The dataset did not take much time to set up, due to the number of records written. Nevertheless, once the dataset has been normalized, it took only a couple of seconds to give the score of each activation function used.
Fortunately, the results of this dataset are reasonable but a real dataset allows us to meet the model's potentials and gain more knowledge about the case we are going to solve.
I have also tested and interviewed the neural network with two subjects.
The more experience the program gets, the better decision it will predict.

Chapter 6

CONCLUSION

This thesis outlines the use of artificial intelligence for collective settlement of debts. In January 1st 1999 the Belgian act on collective debt settlement entered into force. For the debtor who faces excessive debts, the Belgian legislator has created a procedure that allows him to reform his financial situation and at the same time offers him and his family, a fresh start. With respect to the settlement plan, the Belgian legislator prefers an amicable plan. This is a plan proposed by the debt mediator to the debtor and the creditors. When an amicable solution cannot be reached, because the debtor and the creditors are disagree, the judge impose a judicial plan. The law establishes a time limit between three and five years. This time limit may be extended by the judge. This duration can be calculated using a formula invented by Denis Maréchal. The formula is named 13.

The idea of this work is to integrate the technologies with law and make the Belgian court opens into digital life with flexed, secure and stable tools. We chose the settlement collective of debts as a case of study. This case enables us to understand the environment of law. It is sometimes hard to make a decision without returning to the sources. We have made 2 projects to be a perfect sources for the judge: First, a website aims to support the judge to make his decision and to demonstrate the impact of any decision that he makes. Second, a deep neural network aims to make the final decision rather than judge.

The website with its simple interfaces works to collect the necessary data and shows to the effect of changing the duration to repay the debts. The website has been introduced, beginning from the general requirements, its architecture and technological choices are mentioned in detail. The website is tested and evaluated. The interfaces including several parameters and functions were introduced. The website consists of pieces written in different languages: HTML, CSS, PHP, MySQL, and JavaScript. Each language is the best solution we need to a particular feature in the system. Using the right language for each task leads to simpler and easier to maintain code than stretching the abilities of one language to its fullest. The implementation of the two sides of the website, backend and frontend, has been detailed. The whole code is available on the Github: https://github.com/UNamurCSFaculty/memoire-dania-otri/tree/master/Decision%20Making%20Assistant-Website.

The deep neural network is the base of our second project. The conceptual framework design was implemented in Python to profit from its environment. The concept of the project architecture represents the majority of the time spent on this work. Having a good code and making sure that the dataset is adequate, will help for having a good result. Currently, the project contains one model. The model was trained and tested during the execution of the project. The full documentation of the Python implementation is available on the GitHub repository of the project: https://github.com/UNamurCSFaculty/memoire-dania-otri/tree/master/Debt%20Repayment%20Predictor-Deep%20Neural%20Network.

Artificial intelligence will transform our daily lives. The question is whether this transformation will be positive or negative. The development of artificial intelligence technologies expected to be reliable, secure, benefit everyone and to ensure that everybody can enjoy them equitably. But the potential of AI for good does not lie exclusively within its technologies. It lies mainly in its users. If we trust how

our societies are currently being run then we have no reason not to trust ourselves to do well with these technologies. We've been in this research through the AI definitions, basic structure, training methods and activation functions of AI. This is not the end of AI, there is more to come. Who knows what the AI can do for us in the future. Our society maybe will be built on robots.

Our case of study is up to date. On the RTBF site, an article was published on September 28, titled "the justice of the peace rather than budget counters" [77] includes: a procedure will allow the justice of the peace to evaluate if consumer rights have been respected. And to propose the installation of an electricity counter that communicates with the remote prepayment function. This procedure calls for a reasonable payment plan, debt mediation, when the situation requires it. This decree provides the intervention of the justice of the peace before any power cut in case of failing to pay. It also accompanies consumers in debt repayment plans. It means, there is no limit duration in some exceptional cases to repay the debts (translated and summarized by me). It seems to me that justice will support over-indebted people until the last moment.

This thesis has laid the blue prints to integrate the artificial intelligence with the justice. There are much work to do to give the justice domain a chance for being a part of digital world.

On one hand, the deep neural network would most definitely benefit from a real large dataset. Such a dataset will improve the DNN extremely, in terms of training and prediction. To utilize a bigger dataset, the deep neural network would work better by adding more hidden layers. The programme also could have an interface to insert a new set of data instead of editing the code directly. This makes the DNN more flexible and easier for non IT experts.

On the other hand, the website needs more upgrades to satisfy the user. One security way is the judge has an account with password. When a creditor applies a complaint for repayment, the software must include a tab for listing creditors and processing their debts, depending on how many debtors each creditor was loaned from. The website could also include the average expenses of Belgian citizen statistically to give the judge a better point of view. Another feature could also be integrated, which is to calculate and sum up the monthly required payment for each creditor. A wider range of evaluation would give us a bigger insight to understand what makes the website better.

In this thesis, I have got the opportunity to get acquainted with several concepts related to law and computer science. Combining both domains have been totally exciting from a scientific perspective. As final words, I will end my work with this quote: "The best way to predict the future is to implement it." — David Heinemeier Hansson.

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