Département de Génie Électrique & Informatique

Scientific report

Development of a low-cost Escape Game on A.I.

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Abstract :

This paper provides an overview of Artificial Intelligence and discusses definition and history, the main techniques of AI algorithms, as well as its current use in society. Possibilities and estimations on AI future developments are shared. Then, the project of developing an online escape game based on AI is presented.

Contents

Introduction

Philosophers have been trying for over two thousands years to understand how human mind works. Today, this question is still unanswered. Some people think that machines can do the same as humans. Others claim that behaviour as love, moral choice or creativity will always be beyond the scope of any machine [1].

Artificial Intelligence is a new form of intelligence, created by people that sees the world through Big Data. With the increasing number of connected objects and the digitization of our world, Artificial intelligence will become more and more necessary [2].

First, we will introduce the different definitions of Artificial Intelligence as well as its foundations and origins. Then, we will study how AI works through problem solving, reasoning and learning and we will discuss the adaptation of AI in our society, questioning ethics. Finally, the escape game and its enigmas will be presented as well as the feedbacks we obtained when testing it on different audiences.

1 Artificial Intelligence : Definitions, foundations and origins

1.1 Definition of Artificial Intelligence

To define properly AI, we first have to define what intelligence is. Intelligence can be defined as someone's ability of understand and learn things, or the ability to think and understand instead of doing things by instinct or automatically. [3] The first definition specifies clearly that intelligence is specific to humans, but the second one gives some flexibility, it does not specify whether it is specific to someone or something. Therefore, AI can be described as a science that has defined its goal as making machines do things that would require intelligence if done by human. According to Stuart Russell and Peter Norvig [1], AI can also be explained with four categories: Thinking Humanly, Thinking Rationally, Acting Humanly and Acting Rationally.

We first have to define what "think like a human" means to determine if a machine can do the same. There are three ways to do this: through introspection by trying to catch where our own thoughts go, through psychological experiments by observing how a human acts, and through brain imaging. Once we know how a human thinks, we can analyse if the program's behaviour matches the corresponding human behaviour.

The Turing approach in 1950 [1] can explain what acting humanly means. Alan Turing defined the intelligence of a computer as the ability to achieve human-level performance in a cognitive task. A computer passes the test if after some questions asked by a human interrogator, this one cannot say if he is talking to a machine or a person.

Thinking rationally [1] means thinking in a logic way, in an irrefutable way. AI uses symbolic logic to capture the laws of rational thought as symbols that can be manipulated. Acting rationally means acting to achieve one's goals. A rational agent is something that acts to achieve the best outcome. Logical approach can be used to help finding the best action. Sometimes it is complicated to achieve the perfect rationality, so the goal is to find the best outcome with the information and resources we have.

These four approaches have been followed in the past by different methods and different people.

1.2 The foundations of artificial intelligence : the disciplines that contributed ideas and techniques

1.2.1 Mathematics: what can be computed?

Logic, calculation and probability are three essential contributions of mathematics to artificial intelligence.
It is indeed important to distinguish the functions that a machine can calculate or not. Then, even if the notion of calculation [1] is crucial, the notion of tractability also has a big impact. The tractability [1] is related to the time necessary to solve a problem. If it grows exponentially, it is better to subdivide the problem in tractable sub-problems. Finally, the theory of probability plays an important role to predict possible results and to address uncertain measures and incomplete theories. An important progress was proposed by Thomas Bayes and consisted in updating probabilities from observations.

1.2.2 Economy: how did people make choices that lead to preferred outcomes?

Economy is not just a science of money, but also includes the study of how people are influenced by profit when they make choices. [1] The process of decision making is one of the biggest issues of Artificial Intelligence. Herbert Simon, one of the first researcher in AI, won the Nobel prize in economics in 1978 for his work on making decisions that are not optimal, but satisfactory. He shows that if humans are influenced when they make decisions about money, then machines have to copy this behavior.

1.2.3 Computer engineering: the need for effective programmable machines

The concept of intelligence [1], and a programmable machine are essential elements for setting up an AI. There have been immense advances in the field of computer science in the previous years, the biggest improvements concern speed, performance, power and price. Computer software provides different programming languages, operating systems and all the necessary to write programs that are essential for AI.

1.2.4 Control theory and systems theory: how can a system operate alone?

One of the objectives of AI is to create systems than can act optimally and alone, without the intervention of a human, towards a given goal. The goal is to create homeostatic devices with feedback loops to achieve stable and adaptive behaviour. [1] It is used in stochastic control to maximize an objective function over time.

1.3 Historical origins

1.3.1 The gestation and the birth of artificial intelligence

In 1943, Warren McCulloch and Walter Pitts proposed the first model of artificial neurons and have shown that it can compute any programmable functions and any logical connectives [1]. It is the first project in history that can be considered as related to artificial intelligence. Few years later, Alan Turing introduced the Turing Test, which permits to verify a knowledge-based system. [3]

1.3.2 First days success

In 1956, ten researchers [3] specialised in computer science, machine intelligence and neural nets, gave birth to a new and separate science: Artificial Intelligence. The following years marked a great success dominated by the study of these ten pioneers. John McCarty, the inventor of the term "Artificial Intelligence", defined LISP which is one of the oldest programming language which is still used. He also presented a program called the Advice Taker which can resolve many problems as for instance generate a plan to organise an airport. And most importantly, the program has been able to accept new knowledge without being reprogrammed.

The General Problem Solver [1], one of the biggest projects of these years, was handled by Newell and Simon. The goal was to simulate human problem-solving method, and it was the first program that could separate data from problem-solving methods.

After these years of success and great expectations, the first difficulties appeared to solve more complicated problems such as translation.

1.3.3 Artificial intelligence today

Today, the power of a nation is more determined by the knowledge it possesses than the number of soldiers in its army. So, after 1980, countries began operations to introduce AI in industry [1], and companies invested million dollars to use or investigate in expert systems. Since the beginning of the 21st century, the vision of AI has changed a little bit because of the availability of greater volumes and sources of data. [1] Many problems have moved from complicated algorithms or hypothesis-based approach to a data first approach thanks to Big Data. Big Data is a term that describes the large amount of data available and the organisation that is required to analyse this data. All this information enables algorithms to fail faster and thus, to learn faster.

2 Problem solving, reasoning and learning

2.1 Algorithms making artificial intelligence

In order to understand better the link between AI and problem solving, the key is to approach some algorithms with different objectives and applications. Most of them can either be used for supervised or unsupervised learning. However, they can also be used for problem solving purposes without a real learning, like the map application finding the shortest way to go somewhere on a smartphone.

2.1.1 Linear and multiple linear regression

A linear regression (Figure 1) consists in finding a relation between an explanatory variable and an explicated variable.[4] For example, an explanatory variable could be an exam grade and an explicated variable the amount of time spent studying this exam. Thanks to the linear regression, it is possible to predict the next grade by considering the studying time. The regression becomes multiple linear when various explanatory variables are used. [4]

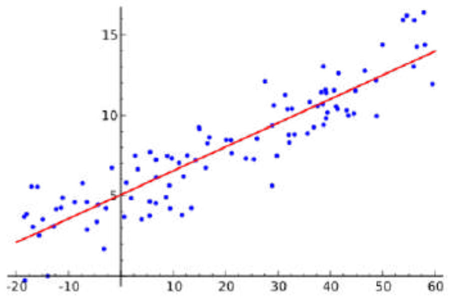

Figure 1: Example of linear regression

2.1.2 Gradient descent and Tabu search

The gradient descent (Figure 2) is an algorithm used in several domains related to optimization and problem solving. The objective is to find a local minimum of an error or a cost for example. By multiple iterations, the algorithm is trying to find a global minimum and therefore the best solution.[4] Since this technique is using the derivative of a function, it reaches a minimum depending of where the descent was initialized and the search time can be long if too many starting point have to be tested.

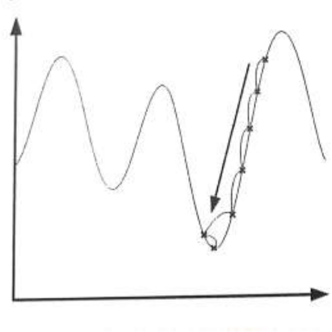

Figure 2: Gradient Descent [5]

The Tabu search (Figure 3) is an upgrade of the gradient descent because it does not stop at the first minimum encountered but is avoiding all the points already "visited". [4] It is going all the way in the function in order to find the global minimum.

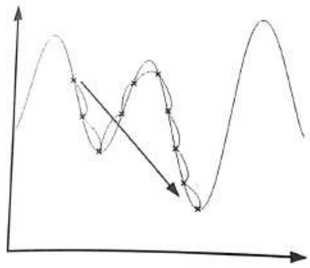

Figure 3: Tabu Search [5]

2.1.3 Bagging and boosting

The bagging is more a method than an algorithm but its objective is the same. It consists in dividing the data in several samples and applying a different algorithm for each one of them.[4] Then, a mean is made between the results and leads to a solution.

The boosting uses the same technique as the bagging but is giving a grade to an algorithm if what he found was close to the expected solution.[4] It is mostly used for supervised machine learning and not only for problem resolution.

2.1.4 K-nearest neighbours

This algorithm is about classification and is quite simple to understand. Classification is the fact to identify the class of an element but this notion will be explained more in details later. A certain number K is chosen and determines how many neighbours have to be considered.[4] In the end, this technique gives a group of a certain observation with the K observations closest to it.

2.1.5 K-means

The K-means algorithm (Figure 4) is one of the most used among the clustering algorithms. These algorithms try to find homogeneous groups for elements based on their characteristics. A number K of clusters is given to the algorithm which is going to compare the distance between each data in order to determine K "centers". Then, all the data is automatically put into the cluster it belongs to.[4]

2.1.6 Mean shift

This algorithm has the same objective as the previous one which is to determine clusters for several observations. This is based on the "shifting window" notion which is defined by a center (chosen randomly) and a radius of action. The window moves by changing its center to go to an area with a higher density of observations.[4] When the window can't find any better area, the cluster is found.

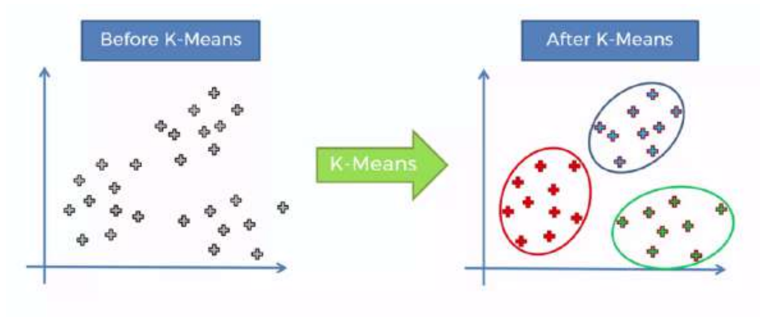

Figure 4: Application of the K-means algorithm

2.2 Supervised learning

Supervised learning is one of the most commonly used learning technique when talking about machine learning. This technique gives some examples to the algorithm so it can try to find an answer and compare it with what was expected. In order to make the algorithm learn, many information are labelled by a human and the algorithm has to learn from those data.[4] Two different tasks can be asked to the learning algorithm and are going to be exposed in this subsection. The first one is the regression which is all about prediction of a value based on data. The second one is the classification that requires the algorithm to identify the class of an element based on its attributes.

2.2.1 Regression and some examples of application

The principal objective of the regression in machine learning is to predict something based on data given and explained by an user.[4] This data is called "labelled" and once it is, it can be used for learning. Regression is often associated with some notion of mathematics as explained in the part dedicated to linear regression. The algorithm tries to match a certain mathematical model as a line or a polynomial. In regression, many things can be predicted : the amount of rain for the next day depending on the meteorological information, the price of an apartment according to its characteristics or, as we saw in the previous part, an exam's grade depending on the amount of time studying.

2.2.2 Classification

Concerning classification, the algorithm has to identify the class of an element. There can be two classes or more. For example for the identification of a hand-written number, there are ten different classes for the element, the numbers from zero to nine. In the case of two different classes, the algorithm tries to find a line like for the linear regression but instead of going close to the dots, the line separates the elements in two groups.[5] However, this technique has boundaries as it becomes less effective when there are several classes or when the dots' distribution is more complex with no real separation. In these more complex cases, some algorithms described earlier like the K-nearest neighbours can be used to identify the class of an element.

2.3 Neural network and Deep learning

In this section, the notion of neuronal network will be discussed as well as how Deep learning can use these networks. The first one has been invented in 1957 and is called the Perceptron. [4] This invention converted the operation mode of biologic neurons into an algorithm and will be discussed in the first subsection. Then, two different forms of neuronal networks, that are more complex than the Perceptron, will be exposed as well as their application. Both can be qualified as Deep learning because they are neuronal networks with a high number of layers (hence Deep learning).[5]

2.3.1 The Perceptron or the neuronal network basics

The Perceptron is an algorithm and more particularly a supervised learning one. The Perceptron has two different neuronal layers: input and output. It can also be called a formal neuron and can only realize classifications on observations that can be linearly separated. [4] For simplicity, the neuron receives some inputs and furnishes an output depending of several characteristics that are listed below :

- Weights that are given to each inputs to measure the importance degree for each one of them.
- A net sum that allows to have only one value depending on all the inputs and their weights.
- A bias indicating when the neuron is supposed to become active.
- An activation function that makes the link between the net sum and the bias to have only one unique output value.

Now that the Perceptron is described as a neuron (Figure 5), several of them can be assembled to form the most simple neuronal network. It contains p formal neurons related to n inputs which ends up giving p outputs.[5]

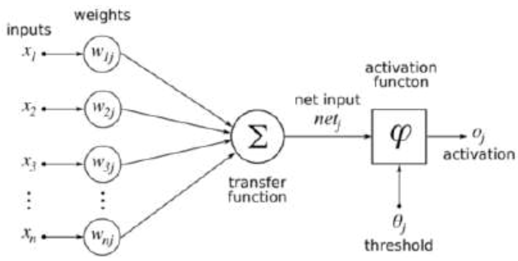

Figure 5: Formal neuron

The two main characteristics of a neuron are its weight and the bias. However, another parameter that can be quite different depending on the neuron is the activation function. The most used ones are presented below [5]:

- The Heaviside function is the most simple as it gives value equal to 1 if the sum is superior to the bias. Otherwise it is equal to 0. This function is similar to a step.

$$f(x) = 1 \quad \text{if x > Bias}$$

$$f(x) = 0 \quad \text{otherwise}$$

- The sigmoid function which is equal to 0,5 when the sum is equal to the bias. It uses an exponential and is mostly used for logistic regression.

$$f(x) = \frac{1}{1+e^{-x}}$$

- The Gaussian function that has a maximum for the bias value and is centered around it. The values of k and k' depend of the standard deviation wanted in the following expression of the function.

$$f(x) = k.e^{\frac{-x^2}{k'}}$$

2.3.2 Convolutional neural network (CNN)

The convolutional neural networks (Figure 6) are deep neural networks used for deep learning and more particularly for visual imagery analysis.[5] They are using the fact that the pixels are mostly not independent from one another and can be treated as several areas. These networks are using several layers of neurons that are dedicated to different tasks. There are three kind of layers : the convolution layers treating the different areas of the image, trying to find characteristics for each of them, the pooling layers using the outputs from the convolution layers to define more precise characteristics and then the more classic classification layers.[5] However, these networks are not easy to train from scratch and an already trained and preexisting version is often used on a new data set of images. This is called a transfer learning. [5]

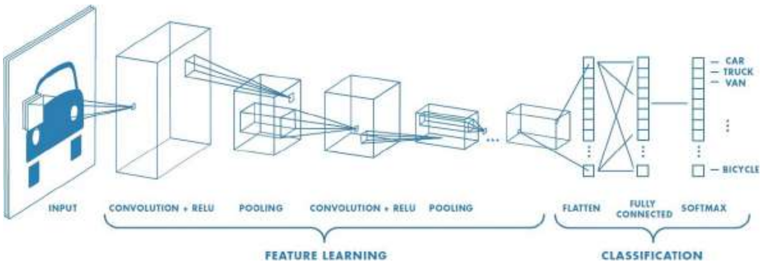

Figure 6: Example of CNN

2.3.3 Recurrent neural network RNN

The second kind of neural network related to Deep learning is the recurrent neural networks (Figure 7). Their particularity is to have connections with the next layers but also with the previous ones. This allows to reuse some information that was treated at some point in the future. This technique also assures that there is a dependence between the outputs and an effect of memorisation. [5] However, these networks can be complicated to adjust because the temporal aspect does not facilitate the algorithm to learn. Nowadays, these networks are used in many domains such as speaking treatment, translation or the chat bots used on twitch and many other websites. [5]

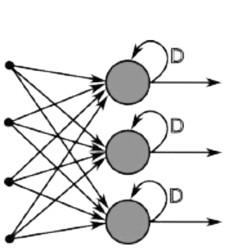

Figure 7: Example of RNN

2.4 Unsupervised learning

Unsupervised learning is a machine learning technique that can be defined as one that does not include any type of labeled data like a supervised learning would. It detects and analyzes relationships and patterns between elements, which a semi-supervised[1] learning could miss. [6]

[1]Semi-supervised learning is using only part of an AI's database.[6]

2.4.1 Decision trees

Decision trees (Figure 8) are a graphical representation of the classification of objects, described with attributes and features. Apart from classification, such trees can also be used for regression. The term "tree" can be explained by how they work: top-down, a series of test are made in order to predict a result. For each test, data is shared in subsets and a mean of the value is made to do a prediction. A grouping of decision trees working in parallel is called a random forest.

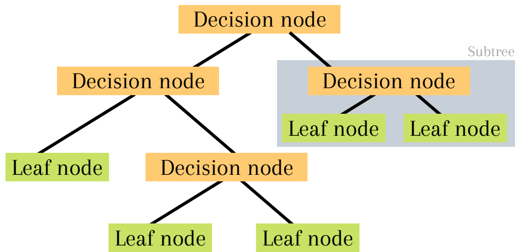

Figure 8: Decision tree

The concept of decision trees will be introduced by presenting clustering trees, used for classification. The leaves of the tree are the different classes while the branches usually contain the conditions for classification. [7] The Figure 9 presents an example of an unsupervised learning decision tree. The hierarchical classification of data is represented by a tree structure. The algorithm is using an "adaptive learning of non-stationary data". [8]

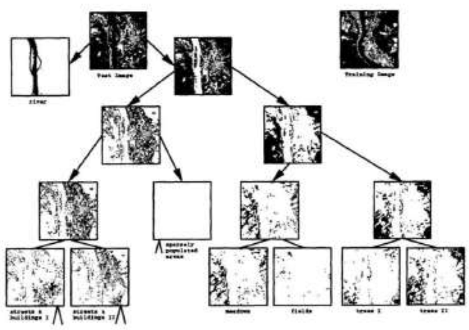

Figure 9: Hierarchical segmentation of an image [8]

While for unsupervised learning decision trees, class information is not taken into account and each test takes every attribute and feature in consideration, it is almost the opposite for supervised learning decision trees. Such trees are used for regression for example. To cite some of the best-known algorithms of supervised learning: CART and C4.5. [7]

The learning system of decision trees can be divided into two steps. First, an algorithm takes care of building the tree, and then an other algorithm tries to simplify the previous tree by reducing its error. This second phase is called the pruning. [9]

2.4.2 Metaheuristics

The term metaheuristic has its roots in the Greek words *meta*, beyond, and *heuriskein*, find. There is no clear consensus on the exact definition of metaheuristics. We could adopt the following definition: “A metaheuristic is formally defined as an iterative generation process which guides a subordinate heuristic[2] by combining intelligently different concepts for exploring and exploiting the search space, learning strategies are used to structure information in order to find efficiently near-optimal solutions.” [11]

It is to be know that metaheuristics are not a guarantee for optimal solutions, but "may provide near-optimal ones in a reasonable amount of computing time". [12] The strategy followed by metaheuristics is to determine optimal points. To guide the search process of an optimum, it can use the experience accumulated during the search. [10]
A significant part of the existing metaheuristics are nature-inspired, as for example the genetic algorithms and the ant colony optimization (ACO), which will both be discussed afterwards. Nowadays, metaheuristics are being used in a lot of different fields such as telecommunications, logistics, smart cities, transportation and many more. [12]

Ant colony optimization (ACO): The ACO (Figure 10) is one of the most famous metaheuristic. It mimics the way an ant colony find its way from their nest to food and back, and how an ant is influenced by the behaviour of its colony thanks to software ants or ant-like agents. A colony is able to determine the fastest way to get to the food source since ants communicate by letting their pheromone where they pass. The optimal solutions searched by the metaheuristic is simply the shortest route. This metaheuristic is used for data clustering for example. [13]

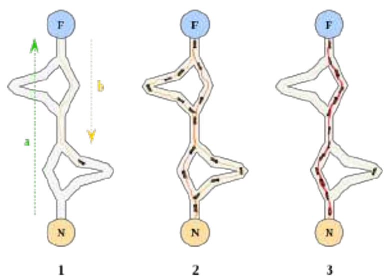

Figure 10: Ant colony finding the shortest path to food [14]

Machine learning and metaheuristics are tightly related since one is often used to improve the other. This is called hybridization and will not be discussed in this document. [12]

2.4.3 Genetic algorithms

It is no surprise that genetic algorithms (GA) are nature-inspired and derived from natural evolution. In its original meaning, genetics is referring to "the mechanisms responsible for similarities and differences in a species". [15]

Genetic algorithms are "probabilistic search procedures" using stochastic search methods based on natural genetic systems. Like metaheuristics, genetic algorithms search for an optimal value. Nevertheless, the peculiarity of GA is that they are designed to work on large spaces, doing a multi-dimensional search on a limited sample of function values. From this function values, the methods generate a new set of samples. [16] These algorithms are constantly treating multiple solutions and compute the function values corresponding to them.

[2] By heuristic, we understand a specialized technique depending on the problem to solve. [10]

Nowadays, genetic algorithms are part of many different fields such as machine learning, image processing or pattern recognition.[17] These algorithms can be used for clustering or handwritten word recognition for example. They are also helpful to deal with feature selection problems, combining different optimization objectives: multi-objective GA. [18]

2.5 Intelligent agents

2.5.1 Agent definition

An agent [19] is an entity, or a system situated in an environment and that is able to achieve goals in an autonomous way. It can perceive its environment through sensors and can act on it through actuators.

An agent has different inputs [20] that are: its abilities, its objectives, its prior knowledge and its observations from the environment and past experiences. Then the outputs are the actions. From all the inputs, the agent will analyse the possibilities [21] and will take a decision for the action.

The agent's function that maps percept sequence to an action allows to analyse how the agent behaves. The percept sequence describes the full history that the agent has perceived. The agent's action is generally defined thanks to all the percept sequence it has in its history.

An intelligent agent is an agent that can learn and use its knowledge in order to achieve its objectives [20], that does the right thing, that learns from experiences and that is flexible to the change of environment or objectives.

Finally, when several agents are present in the same environment, we speak about multiagent world [21]. Autonomous intelligent agent can cooperate with other agents to achieve their own task or to accomplish global task they have in common.

2.5.2 Environmental impact

Task environments can simply be defined as the problems resolved by rational agents. Task environments aggregate sensors, actuators, environment and performance measure. We speak about PEAS (Performance, Environment, Actuators, Sensors).

The first step in the conception of an agent [1] is to specify the environment.
The task environments [19] are various but can be affected in different groups like the observable one, the deterministic one...

2.5.3 Basic kinds of agent programs

The goal of artificial intelligence [1] is to design agents that work intelligently. That means that AI has to implement the agent function that will take place in computing devices. So, the agent is composed by the architecture and the programs.
It is important that agents are created for complex environments [20] so that they can act in the same kind of environment as humans.

Programmed agents: The particularity of a programmed agent [1] is that it receives the actual percept from the sensors and not the totality of the percept (percept history). That means that if it needs more information it has to remember on its own the previous percept sequence.

Simple reflex agents: The simple reflex agents [1] choose actions after receiving the actual percept. They ignore the percept history. This type of agent uses the condition-action rules. Depending on the actual percept and the condition-action rule, the agent selects an action to perform by the actuators. We can distinguish the acquired and the innate relations. The agent can acquire and implement the relations by creating relations between the percept and the action.

However, the simple reflex agent has a limited intelligence [19] and can only make decisions if all the necessary conditions are present.

Model-based reflex agents: This agent [1] has an internal state which depends on the percept history. This internal state is regularly refreshed. This update depends on the one hand on the evolution of the environment independently of the agent and on the other hand on the impact of the actions on the environment.

Goal-based agents: The agents [1] often need to know what the goal to reach is. That is why the goal-based agents share the actual percept, the goal and the model (the same as the model-based reflex agents) to select actions.

Utility-based agents: The objective of an agent [1] is not an sufficient information when it can be reached by different ways. That is why we can introduce the notion of utility which refers to the satisfaction of the agent depending on its performance. The agent owns a utility function which classifies the performance measures. The best action will be reached when the internal utility is the same as the external performance measure. A utility-based agent chooses the action which maximizes the expected utility.
All these programmed agents can improve their performance by learning.

Learning agents: In the AI domain, we often focus on creating machines that have the ability to learn [20] and then to educate themselves. In this case, the machine can operate in unknown environment and can be more and more efficient. All the learning intelligent agents modify their components in order to improve their performance [1]. They also improve the machine thanks to critical feed-back (success or failure of the action). The learning unit and the performance module that select the actions are linked, and each one impacts the other.

3 Artificial intelligence in our society and the ethical questions it raises

3.1 Artificial intelligence in the service of mankind

AI has been getting more and more impressive over the several last years. There have been major advances in everything from game playing to speech recognition to identifying faces. Zipline, a startup company, uses AI to guide drone to deliver blood to patients in Africa : a fantastic application that would have been out of the question a few years ago [22]. Among the main application fields of AI, there are transport, medicine and personal smart agents.

3.1.1 Transport

Nowadays, embedded systems are everywhere in our cars : GPS, speed controller, captors, radars... Self-driving cars are just the logical next step of the ongoing evolution. The main objectives are [2]:

- improving road safety
- improving traffic flow
- optimizing the time spent in transport

Since 90 % of road accidents are caused by human mistake (according to the National Highway Traffic Safety Administration) [23], improving road safety is the number one motivation for autonomous cars. Indeed, these vehicles respond faster and more reasonably (no more unpredictable behaviors) when facing a danger. The next 10 years will be decisive in transport revolution, but some legal and ethicals concepts have to be clarified such as [2]:

- responsibility in an accident, since the driver would not be directly responsible
- how should the self-driving car react if it has to chose in a situation where different people are involved
- technological risk associated with hacking

GAFA [3] and car producers have already invested billions euros and dollars with the objective that a child born today would not need to get a driver's license.

For now, the driverless cars that do exist are still restricted to highway with human backup because the software is too unreliable. [22]

3.1.2 Medicine

With more than 3000 articles indexed every day on the PubMed [4] database [2], the knowledge that every health professional needs keeps increasing. It is almost impossible for a human doctor to be up to date on the latest medical information. AI is with no doubt one of the best way to solve this issue, analysing all the information available and helping doctors to set up treatments and protocols for each disease. Especially knowing the fact that in 46% of the cases [24], IA works better than human diagnostic, according to a study comparing clinical predictions and statistics.

So far, connected objects such as tensiometer or pillbox are a reality but each one works with its own application, there is no unique communication protocol that allows to share data in the same format. Curative medicine (that treats the disease only when it appears) could be replaced by predictive and more personalized medicine based on Big Data and AI. Diseased people could be equipped with sensors connected to IoT [2] and have medical information in real time.

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[3] Google, Apple, Facebook, Amazon

[4] PubMed is the main search engine for bibliographic data in all areas of biology and medicine.

3.1.3 Personal smart agents

A personal smart agent is an application which function is to help people in the daily tasks [2], with the following characteristics :

- a degree of autonomy controlled by the user
- a strong capacity to react to a changing environment
- a capacity for collaboration with others software agents or humans
- an auto-learning capacity, to constantly improve the task execution

Google Assistant, Apple with Siri and Microsoft with Cortana are examples of big actors developing their own intelligent agent, having in common one thing : machine learning.

3.2 The fear of being overwhelmed by artificial intelligence in our daily lives

While for most scientists AI is the solution in the foreseeable future, others fear the potential danger of it. One recent bestseller by the Oxford philosopher Nick Bostrom warns about a super-intelligence taking over the world and Stephan Hawking warned that AI could be "the worst in the history of our civilization". [22]

3.2.1 Historical fear of technological progress

In the modern history of mankind, discoveries and technological progress have often been accompanied by setbacks and unintended negative side effects [1]:

- nuclear fission brought Chernobyl and other nuclear disasters, as well as the threat of global destruction;
- the internal combustion engine brought air pollution and has contributed to global warming;
- in a sense, cars can be considered as robots that have conquered the world by making themselves indispensable.

All scientists and engineers are faced with ethical considerations about how they should act in their work, what projects should or should not be carried out and how they should be treated. AI, however, seems to raise new issues that go beyond anything we have ever faced before.

3.2.2 People might lose their jobs to automation

Today's industrial economy is increasingly based on the use of AI and task automation. This could suggest that thousands of workers have been replaced by the use of computers and AI programs. But in fact, automation through information technology in general and AI in particular [1] has created more jobs than it has suppressed. Its use is in fact essential, because human labor would add an unacceptable cost to the daily tasks managed by AI.

Now that the use of AI tends to develop more as an intelligent agent in the service of humans, we have less to fear about job loss than when AI was focused on "expert systems" designed to replace humans.

According to the AI experts [1], the next challenge is the creation of human-level AI that could pass any employment test rather than the Turing Test. That would mean the creation of a robot that could learn to do any one of a range of jobs, but we are not there yet.

3.2.3 Systems and technologies might be used for undesirable purposes

Once again, when we look at the evolution of technology, we realize that advanced technologies have often been used by the powerful to suppress their rivals. The use of AI for undesirable purposes leaves some ethical questions unanswered.

In the army: the U.S. military deployed over 5,000 autonomous aircraft and 12,000 autonomous ground vehicles in Iraq [1]. This fact raises the question of fairness on the battlefield, when vulnerable humans are fighting against powerful machines. This may suggest that new methods of combat could emerge, and could lead to a new kind of arms race. Robotic weapons pose additional risks: as soon as the human decision making is taken out of the firing loop, robots may end up making unreasonable decisions, which could lead to the killing of innocent civilians for instance.

Concerning speech recognition technology, the massive use of AI could lead to widespread wire-tapping, and thus to a loss of civil liberties. Nowadays, AI has the potential to mass-produce surveillance. [1] For instance, the U.K. now has an extensive network of surveillance cameras, and other countries regularly monitor Web traffic and phone calls.

3.2.4 The loss of responsibility for machine decisions making

There is a form of blockage in some people when it comes to reversing the standard partnership between human and machine. [24] The approach would be to let computer algorithms and systems make the decisions, sometimes with human input, and allow computers to ignore them when appropriate. Some believe that this approach is dehumanizing, that it marginalizes and diminishes the human. However, it has been proven that this method gives in most cases much better results than when the decision is made in the end by humans (with or without the help of a machine) using their sense of judgement. Humans are by nature attached to their "common sense", but this one comes to bias most decisions.

3.3 Potential evolution of artificial intelligence over the next few years

3.3.1 The success of artificial intelligence disguises its risks

Technology has the potential to do harm when placed in the wrong hands, but with AI, the technology itself becomes dangerous. [1] The question is whether AI poses more risk than traditional software or not. We will look at two main sources of risks:

- The first category of risks is not specific to AI. The AI system's state estimation may be incorrect, causing it not to act as expected. For example, an autonomous car may make an erroneous analysis of the data from its sensors, and not see a car in the next lane, causing an accident. But the same mistake could be done by a human driver, we can not expect from AI to be perfect. [24] The proper way to reduce these risks is to design a system with checks and balances so that a single condition-estimation error does not spread through the system without checking.

- Machine learning systems (and any form of AI) still lack common sense. Some non-rational concepts, such as happiness, are very difficult for any AI to assimilate. Thus, one must be very careful what to ask of an AI, even in cases where a human would have no problem realizing that the request should not be taken literally.

3.3.2 What if AI succeeded ?

So far, AI has enabled new applications such as voice recognition systems, monitoring systems, robots, search engines and personal assistants. Beyond being a simple assistant, AI already addresses some of the biggest societal issues facing society today. For example, AI is a real help for the exploitation of genomic information for the treatment of diseases, or the efficient management of energy resources.

It seems likely that a large-scale success of AI - the creation of intelligence at the human level and beyond - would change the lives of the majority of humanity. The very nature of our work would change, as would our vision of some concepts such as intelligence, and consciousness. AI systems at this level of capability could threaten human autonomy, freedom and even survival. [1]

Public opinion on AI is largely influenced by science fiction writers, who seem to prefer dystopian futures to utopian ones. But so far, AI seems to fit in with other revolutionary technologies of the 20th and 21st centuries, whose negative repercussions are offset by their positive aspects.

3.3.3 Some of the remaining limits of artificial intelligence

Scientists reluctance, as well as public opinion, poses a limit to AI development because it implies to reverse the decision making process between humans and machines.

Uniqueness of human intelligence: by nature, humans do not select data from the senses, all information from sight, touch, smell etc. is processed by our brain. Computers do the opposite: they find it difficult to collect data other than what their designer or programmer has given them access to.

The use of algorithms may amplify prejudices and pernicious biases that exist in society.
Thus, instead of reflecting the conscious discrimination of an individual, there is a bias which could repeat and amplify the discriminatory pattern of decisions made by the millions of people who click on ads, for example. Fortunately, automatic systems can be extensively tested and improved and once corrected, they are unlikely to be wrong again.

3.3.4 Questionning the ethic of AI in society

Boris Barraud, doctor of law from Aix-Marseille University, fears that public power could be replaced by private one [25] since most technologies of AI are designed in the Silicon Valley in order to defend all over the world a particular vision of man and society. Web multinationals and their algorithms are becoming the new guardians of the temple, instead of politicians, police, journalists, philosophers etc...

The power of social networks and major content sharing platforms has become immense, so as the few men who make them work by developing their algorithms. This raises many questions with regard to democracy and fundamental freedoms. It is indeed a question of power: technological and economic power in the face of political power.

In such a context of ethical questioning of AI, society has taken hold of the problem. More and more countries are committing to lifting the veil on AI and its impact on society, notably through the organisation of conferences to raise public awareness and lead to reflection by the crowds. Ethical committees are being established, as well as national programs that aim to frame the development of AI, without hindering it.

In France, a Digital Ethics Committee [26] was created by the government in 2019. Its aim is to address the ethical issues of digital technology and artificial intelligence in a comprehensive manner. This proposal was then part of a framework of reflection on the notion of a positive regulation of AI: to be open to innovation, not to "over-regulate" it in a legal context that is already highly protective, while regulating its ethical issues.

The first thing to be said is that existing ethical principles, and the laws that protect them, must continue to apply in the digital world. However, one way forward for the French committee would be, on the one hand, to help the various existing ethics committees to take into account the consequences of the digital transformations, especially by providing them with expertise, and on the other hand, to reflect directly on the truly new subjects brought by AI and digital technology.

4 Development of an online escape game

4.1 Why an escape game ?

Over the last decade, artificial intelligence has become an active field of research. Even though its use is growing exponentially, only few truly understand what is at stake.
The definition of artificial intelligence as well as its challenges and the issues it raises are still very vague notions to be understood by most. As the effectiveness of non-scientific tools to spread scientific knowledge has been proved, our challenge is to popularize artificial intelligence and refute all prejudices around it in a playful way. The focus is mainly on students of middle and high school.

Keeping that in mind, we designed an escape game on the theme of AI. An escape game is a game to be played in a group built around a succession of puzzles, most of the time to solve a situation or to escape a place.
Since the idea of this project is to make the game accessible to all, the setup uses as few materials as possible, including objects you can easily have access to (smartphone, paper, blackboard, etc.). We decided to make a virtual version of the game, so that everyone can be able to play online. It is focused on a development suitable for schools and universities. All the puzzles composing the escape game revolve around a background story, with a problem to solve.

4.2 Original idea and final development

Our initial idea when we started the project was to make a "semi-virtual" escape game. Thus, the excavation would take place in a classroom with hidden elements prepared by the master of the game (teacher, supervisor, ...). In this version, we thought to use a software serving as a "base" for the escape: the students could interact with the interface only to check the codes they found, and be redirected to the following puzzles. This allows the students to reduce the interactions with the game master, and thus gain autonomy. Some of the puzzles had to be implemented in hardware, using material that is easy to find in a school (boards, prints, cards, ...).

The situation made it impossible for us to implement our escape game as planned. We quickly redirected to a fully digital version (Figure 11), which is the final developed version. All the puzzles are playable online, and are linked by an interactive interface, through which you can make a virtual search of the rooms (example Figure 12) you pass through. The fully digital version was made with the software Genially (http:\genial.ly). It is a free software for the general public that allows the realization of interactive presentations. To access the final version of our project, click here: https://view.genial.ly/5ead4f8b7b8ef50d76d221a4/game-breakout-iascpe.

Figure 11: Introductory page of the online escape game

Figure 12: Example of an interactive room

The Figure 13 shows the game diagram. The game begins with an introduction to the player's mission: find the documents of Professor Bernard, who must hold an important presentation in less than an hour. The player is brought to evolve from a base in different rooms, of which he gains access progressively thanks to codes obtained in game or by searching. The games are enigmas, which cover the theme of artificial intelligence and its stakes. At any time, the player can go back to a room he has already been in to look for clues or redo a puzzle. The total duration of the escape game should be around one hour. On exit, the player is supposed to find the professor's presentation, as well as a debrief on his experience puzzle by puzzle. This shows how the AI concepts discussed are actually used in everyday applications. The website we created for the debrief can be found at this address: https://spark.adobe.com/page/FlH3zPiRNMiZU/.

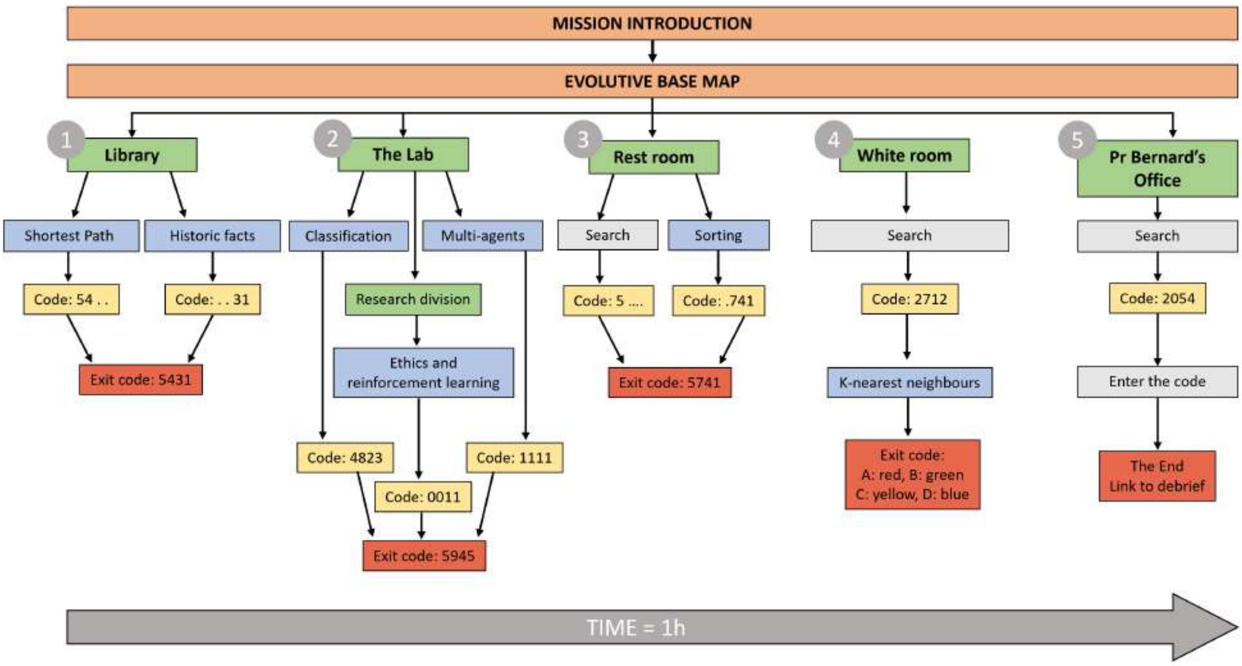

Figure 13: Escape game flow diagram

4.3 Project management

We have organized our work into three main parts. First, research work for the state of the art. Then, a work of reflection on the setting up of the project and the realization of the enigmas. Finally, a practical phase in which we coded the riddles and created the online document to link them together. As for the realization, we brainstormed on how to illustrate with puzzles the different algorithms of AI. Then, we shared the work: each member of the team worked mainly on a puzzle, or on the implementation of the Genially website.

4.4 Enigmas making the game and illustrating AI algorithms

4.4.1 Ethical questions and the reinforcement learning algorithm

This enigma is made to discuss received ideas about AI while reproducing the behavior of a reinforcement learning algorithm. Indeed, once you answer the 6 questions on AI and Ethics, you have the number of good answers but you do not know which ones they match. The agent (you) seeks a decision-making behavior through iterated experiments, that maximizes the number of right answers over time.

It is implemented on Scratch [27], a free programming language where you can create your own interactive stories, games and animations.

For each question (Q1, Q2, Q3, Q4, Q5, Q6), the player has to click on the corresponding ball to answer (Figure 14). Since the game is aimed at French high school students and general public, all puzzles, interfaces and questions have been written in French.

Figure 14: Game interface

There are two choices: false (0) or true (1), as show on figure 15.

Then, pressing ‘a’ on the keyboard will display the next question. Once you are done, you need to click on the avatar to know how many good answers you made. At any time, you can press the red flag to start over. On figure 16, we can see the two options when you answer all questions : the answer is not correct and the number of good answers is printed or the answer is correct and you have the good code for the next step.

Figure 15: Two choices : false (0) or true (1)

Figure 16: Two options : answer not correct or correct

4.4.2 Shortest path

This enigma (Figure 17) was implemented to illustrate what most of the shortest-path algorithms look like. These algorithms are used in a wide variety of domains and their objective is to find the shortest path between two dots in a graph. Some famous applications like Google Maps are based on these algorithms.

Regarding the enigma's form, the main problem is based on a Labyrinth. In this case, the solution is not the path to find the way out but the shortest one to a certain objective. The player must try different possibilities and exploit the rules of the Labyrinth in order to find an -almost- optimal solution. As long as the score is not good enough, the player has to retry until he finds a decent solution. The following figure shows the enigma's interface that has been designed with Qt Creator. We decided to use Qt Creator, because it's a quick and easy tool to create interactive graphical interfaces.

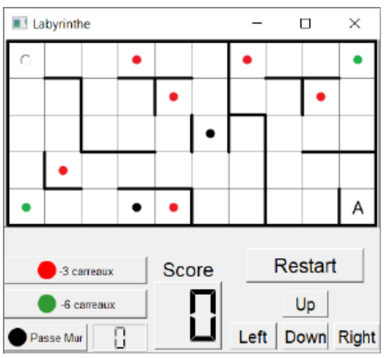

Figure 17: Labyrinthe enigma's interface

4.4.3 Historical facts about AI

In this enigma, the player has to answer to several questions about historical facts. The goal is to learn more about the main step of Artifial Intelligence in history.
The game is based on the famous TV show "Who wants to be a millionaire" (Figure 18). It is possible to get to the next question only by answering correctly. If an answer is wrong, the game starts again from the beginning. Thus, winning the game means answering correctly to all the questions in a row.
This shows the concept of reinforcement learning, because the player must learn from his mistakes to try to remember them and not make them again afterwards.
To implement the game with the historical questions, we used the website LearningApps [28], usually used in order to create ludique ways to teach in class. This tool is really handy to use, and offers reusable educational game templates.

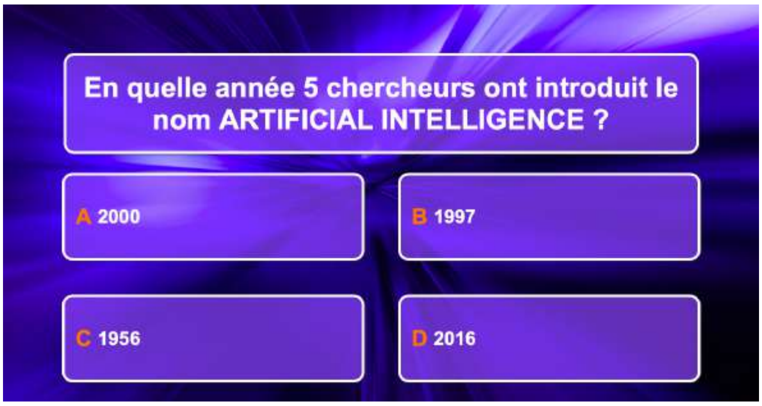

Figure 18: First question of the game

4.4.4 K-nearest neighbours

The goal of the enigma is to demonstrate the algorithm of the nearest neighbours.

The principle of this algorithm is to assign a class to an undetermined entity E depending of the nature of the neighbours.

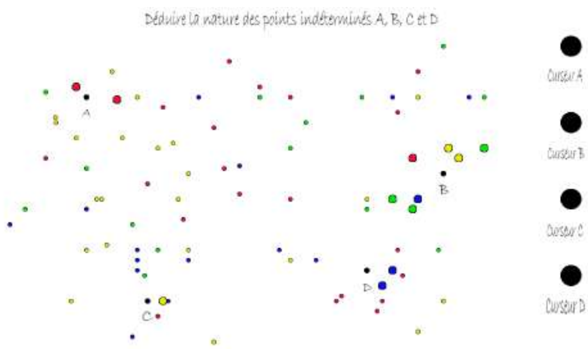

Figure 19: Interface of the "K-nearest neighbours" enigma

First of all, the player needs to find and determine the k nearest neighbours of the entity E.

Then, depending on the k selected neighbours, the player has to discover the class the most represented by the neighbours and to attribute it to the entity E. The nature of E depends on the number k of neighbours we decide to analyse.
For example, if an entity is surrounded by neighbours that are from nearest to furthest away blue, blue, red, red, red, red, red and red in nature. If the number k chosen is 2: the two nearest neighbours are blue so the entity E will be assigned in the category blue. However, if the number k chosen is 6, the entity E will have 2 neighbours blue and 4 neighbours red. Consequently, the player will attribute the entity E in the category red.

By playing to the escape game, the player will discover this algorithm. He/She will select the number of neighbours to be analysed for every point thanks to the cursor. (Figure 19)
The number k changes for the different entity and the player can then determine the nature of A, B, C and D. To implement this enigma, we decided to use the software program Processing (https://processing.org). Indeed, we needed to use a software where there are interactions with the mouse and the keyboard of the computer. The player interacts with the platform.

The original model is composed of the 4 points A, B, C and D surrounded by several points that are red, blue, green or yellow. 4 cursors, one for each point, are also present.

Each time the player presses a cursor, the new nearest neighbours of the associated point appears. When the 8 nearest neighbours have been revealed, there is a reset to the original model.
In the daily life, this algorithm of the K-nearest neighbours is used to solve regression and classification problems.

4.4.5 Sorting and classification

The purpose of this puzzle is to classify photos of flowers into 4 categories. Photos of flowers appear randomly in the center of the game interface (Figure 20). The player has access to a database, to know the attributes defining each category. Example: "Category 1, petals 2 to 3cm long, leaf shape elongated". This step can be similar to tagging data for machine learning algorithms.

Figure 20: Interface of the Classification enigma

Classification is a central problem in machine learning and artificial intelligence. A classification rule is a procedure for assigning an object the label of the group to which it belongs, i.e. to recognize it. Objects in the same class must be "similar" and objects in two different classes must be "distinct".

The algorithm is carried out in two phases. In the first phase (offline, or learning phase), a model is determined from the labelled data. This is what you have done in the escape. The second phase (online, called test) consists in predicting the label of a new data, knowing the previously learned model. Sometimes it is better to associate a data not to a single class, but to a probability of belonging to each of the predetermined classes (this is called probabilistic supervised learning).

Classification algorithms are, for example, used for image recognition. For the identification of a handwritten number, there are then ten different classes for numbers from zero to nine.

4.4.6 Multi-agents

The goal of this enigma is to simulate a multi agent system to show how it is worked. Multi-agent systems are very used in the field of Artificial Intelligence and computer science. But what is an agent? An agent is an entity which can be virtual or real and which is autonomous and interact with its environment. The agent gains information about its environment, so it can decide its activity to achieve a goal. In a multi agent system, the environment is other agents. Most of the time, an agent in a multi agent system has not a full global view but just a local view of the system, which is far simpler to exploit.

We have used the Scratch's application (https://scratch.mit.edu) to code this enigma because it is a very simple software to handle and to use for graphic apllication. An agent is symbolized by a box which can be black or white. There are 9 boxes which form a checkerboard. The goal is to find a disposition of the checkerboard with some conditions on the change of colour for each box.

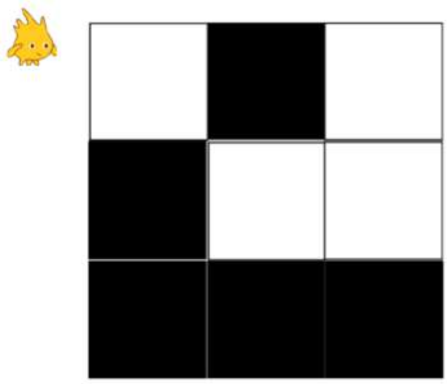

Figure 21: Interface of the multi-agents enigma

Multi agent systems are very used to simulate an environment which evolves in time or behaviours which depend of the environment. It is also used to simplify very complex and large systems. For example, we can simulate the propagation of a disease.

5 Users feedback

We created a survey to get user feedback on our Escape Game in order to improve it. The sample of testers was sixteen people. If we had had more time, we would have liked to have feedback from a broader sample of people. We asked targeted questions to find out if the game is fun and educational enough. The form was created with the *Google Form* online tool.

We asked the players two types of questions.

First, questions about the players' profiles and their feelings about the game and the puzzles in particular. To improve the gameplay, we asked questions to target the puzzles that were too difficult or too easy, and to be able to adapt the level. Based on the feedback we received, we made adjustments, for example by adding clues that appear only after a minute for the puzzles that were considered the most difficult. Following the survey, we also reviewed the possibilities for choosing the historical puzzle, in order to simplify the task. Those questions were used to improve the game, but we will not deal with it in this report.

Second, questions focused on the players' overall experience and their personal feelings about their knowledge of Artificial Intelligence. This is the part we are interested in to know if the overall objective of the project has been achieved, and we will therefore analyze the graphs obtained from the answers to those specific questions.


INTELLIGENCE ARTIFICIELLE
ESCAPE GAME

Qu'avez vous pensé de l'escape Game sur l'IA?

Nous vous remercions d'avoir joué à notre Escape Game. Nous espérons que vous vous êtes amusés et que vous en avez découvert plus sur l'Intelligence Artificielle !

Nous aimerions connaitre votre avis afin de nous améliorer ! Merci de répondre à ce petit sondage pour nous faire part de vos impressions.

*Obligatoire

A quelle tranche d'âge appartenez-vous ? (si vous étiez plusieurs, cochez toutes les tranches d'âge représentées dans le groupe)

- [ ] < 14 ans
- [ ] entre 14 et 18 ans
- [ ] plus de 18 ans

Avez-vous trouvé l'Escape Game ludique ? *

Figure 22: Survey interface to retrieve opinions and comments

The graphics on Figure 23 and Figure 24 show that globally, people have increased their knowledge about Artificial Intelligence. Indeed, the average knowledge on AI before playing the Escape Game is 4.7/10, and after the Game and the final debrief, 6.5/10. Importantly, users found the game playful with an average of 8.5/10 as shown on Figure 25.

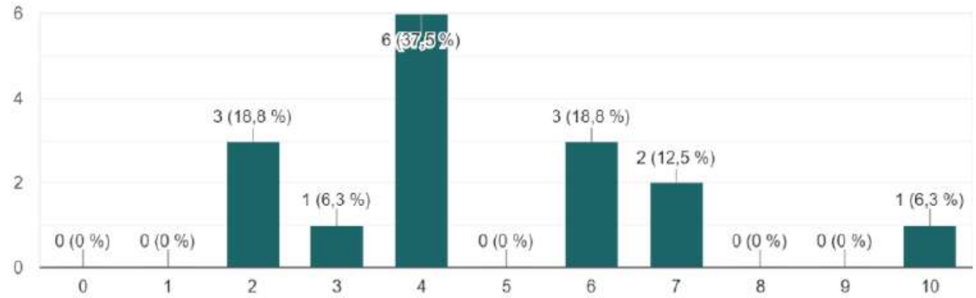

Figure 23: Rate your knowledge on AI before the escape game

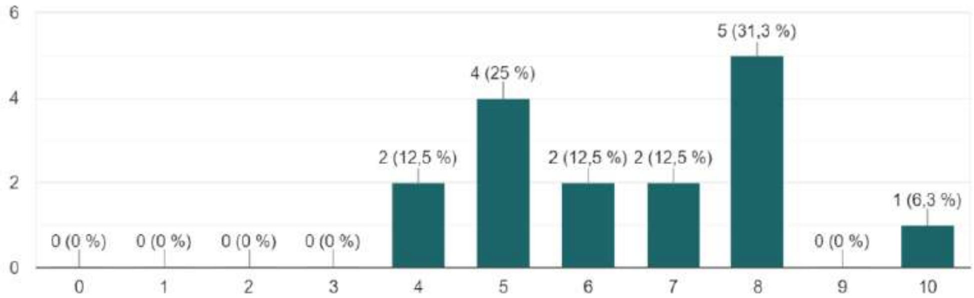

Figure 24: Rate your knowledge on AI after the escape game

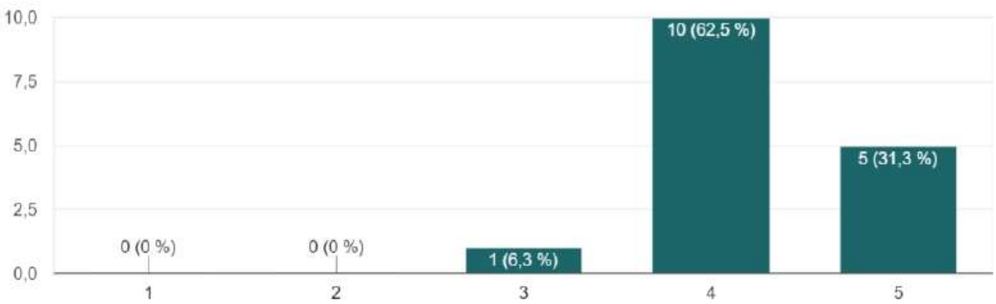

Figure 25: Did you find the escape game playful ?

Overall, and by cross-referencing the results, our survey shows that learning can be fun, yet effective. We can deduct that our project has reached its goal: to inform about Artificial Intelligence, while remaining playful thanks to the escape game and puzzle format.

Conclusion

In this paper, the concept of artificial intelligence was defined, and its foundations and origins have been discussed. Mathematics, Economy and Computer science are the main disciplines that contributed to the development of AI.

Also, there are different types of algorithms which are being used to make an AI. It is with supervised learning, where the examples to be learned are labeled, that neural networks have achieved the best results. But neural networks have made little progress with unsupervised learning, which is the way any human perceives the world. Vision, speech recognition and other features that were once beyond the reach of machines are now available to them in many areas and at levels comparable to humans.

Finally, this paper discusses over an overview of the role of AI in society and the ethical questions it raises. AI is already used in the fields of transportation, medicine and technology with personal smart agents. But there's a breach in AI development, brought on by people and society. We are still in the beginning of AI, and the systems lack common sense to be widely accepted. Governments are becoming aware of what is at stake in the development of artificial intelligence, and are taking steps to inform about AI and control its development, legally, technologically and politically speaking.

Our work is part of this perspective: to inform about what artificial intelligence really is, in a playful way. Our target audience is mainly high school students, but we also share our work freely in open-source in order to make it accessible to as many people as possible. We showed through the analysis of the results from the survey that the project goal was met: we have created an educational escape game on the theme of Artificial Intelligence, which remains entertaining. We anticipate our work to be a starting point for future reflections, and development of any new mean to spread scientific knowledge.

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