Applications of Heuristics as a Scientific Methodology on Military, Medical and Industrial Fields.

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Methodology, Heuristics, Applications, Engineering, War, Medicine, Optimization, Data, Ethics, Strategies, Technique, Solving, Ontology, Expert systems.

Abstract

This investigation was made with the intention of analyzing the application of the heuristic scientific method to different fields, and through that analysis, determine the applicability of the model to each sector by weighing the advantages and disadvantages from each dominion; in order to propose modifications that could help to improve the effectivity. In the same manner, the results will be compared at the end for each of the cases, to see if there is a correlation between the proposed modifications and, if so, evaluate if there is a way to improve the method as a whole.

Introduction

For an artificial intelligence to work, it’s necessary to provide it with an ontology and a heuristic build around it; being so that an ontology is defined as the knowledge or experience pertinent to the field that is previously defined and delimited by a suit of experts in the field; therefore, it can be defined as a: *“Formal specification of a shared ontology.” [1]*

The heuristic is the ability to develop strategies capable of solving problems in a more effective fashion, based on the provided ontology. In artificial intelligence, it strives to develop algorithms that use the rules specified in the ontology to solve problems in a more effective way than by brute force.

To do so in a more reliable way, the heuristic scientific method was developed; it follows heuristical principals, heuristical rules and heuristical strategies.

There are two heuristical principles: on one side, the modelling, which tries to structure the problem in a way that can easily be solved by an algorithm; on the other, the comparison, which analyzes all of the paths to detect if one is following a path that has already been tested or that is exactly the same to one that is being executed, in case this happens, it stops immediately the path and, in this way, avoids unnecessary work.

The heuristical rules are such that must be followed by every algorithm to improve their effectiveness, these establish that: all data must be represented by variables, this variables must be represented numerically (as they are the simplest structures), the searched and the analyzed must be split and saved into different categories, and finally, all problems need to have the capacity to be reformulated as another model.

The heuristical strategy establishes the organization that must be followed by the algorithm; it states that the starting point will always be the information provided at the beginning and that, while the problem is being processed, all the original knowledge must be compared with it, for it to generate new intermediate knowledge.

This method, was used in a general manner in different work fields such as psychology, medicine, industry, physics, historical, military, etc. Nevertheless, it was applied indiscriminately in all the aforementioned dominions, which led to the use of the same algorithm in the medical field to analyze the behavior of a virus and in the chemical industry, to study the reaction of an element in different testing environments.

The application of the method in such a general way led to the exclusion of a lot of variables that are unique to each work field; for example, while the ethical applications of a decision in a war field are a lot, in the physics side, they are not very relevant.

Because of all which was previously said, this investigation will try to define the applicability of the method in a general fashion to each of the fields that will be analyzed, starting form the hypothesis that it could be more appropriate to develop an independent method for each field, instead of simply changing the used ontology.

To do so, each field will be scrutinized by study cases that analyze the relationship between the artificial intelligence and the heuristics used, against the application of the one specified by the regular scientific method. In all of the occurrences, the advantages and disadvantages of the application of a different method will be noted, and an individual conclusion will be built for each of the fields; finally, all the conclusions will be compared to reach a global conclusion.

Analysis by field

Industry:  
  
On the industry, we can encounter diverse cases where the heuristic methodology is effective to optimize processes and supply chains; although, we also find cases where it doesn’t.  
  
In the factories, the artificial intelligence is used to make real time analysis of the production processes; this is made with the purpose of optimizing the processes and correct errors in advance. An example of this is the project ARKUNE, which was made to optimize the mechanized processes on a factory. When it is implemented, an artificial intelligence analyzed in real time the quantity of generated burr to determine if the burr eliminating process needed to be enacted or not. In these cases, the applicated ontology is the knowledge of the limit of approved burr in each product, as well as the algorithm to determine the amount of generated burr. [13]  
Taking this particular case, we can see that the heuristic method is being implemented to carry this process, as the problem is modeled by an algorithm that analyzes the quantity of burr produced by the drill, and once that is determined, it evaluates the burr limit to decide the execution of the next process.  
  
Another example of heuristics on the artificial intelligence used at industries is the one on the color and textile industry. Here artificial intelligence is used on diagnosis of problems and resolution of them. The AI used in this industry uses different methods and implements different approaches of AI to solve the problems. This approaches are Expert Systems, Fuzzy Logic and Neural Networks, but we will focus only on the expert system for now.  
  
Experts System are used to solve problems at the level of the human expert, using the knowledge given to it by an expert on the topic to be treated. A knowledge engineer develops a way to explicitly write this knowledge into the expert system and does it through various iterations. Since there are areas where it is difficult to have complete knowledge and expertise of the objects with which the system will work and ways to solve the problems that may appear, heuristics take a big part of developing an expert system. [14]  
  
It is Heuristic knowledge one of the main ways in which the textile industry develops expert systems for artificial intelligence diagnosis. The expert system and its heuristic knowledge is used on coloring and finding and resolving defects on the textile materials by tracing where the problem may origin and correct the mechanical or electrical system that may cause the problem. This can only be done by using a heuristic of how the textile system works and knowing that a failure in certain system causes certain problems. [17] The knowledge of how to correct the problems is also an example of how heuristics are useful for artificial intelligences in industries.   
Sekisui, a chemical company dedicated to the production of construction materials, decided in 1984 to invest in new technologies and began developing an expert system that could help on the company’s procedures. The resulting system worked on three different aspects: Computer Assisted Design, Consultations System and production control. This expert system helped with each step of the construction process that Sekisui covered, since the design, the decisions made on the materials and pieces used, and finally the manufacturing of them. Expert Systems can be used in different industries and concentration areas, and they work based on heuristic knowledge of the problems to be solve. [14]  
  
Despite the existence of cases and areas where the heuristic method is applicable and works as intended, there are cases where this doesn’t hold true. This is mainly because the heuristic knowledge works perfectly for cyber physical systems in the factory, but when we talk about other systems such as semantic ones it fails to work.  
  
An example of this, are the Chatbots developed by Facebook, where the objective was to test and improve the communication abilities of two artificial intelligences designed to stablish natural conversations. Said program was defined to receive sentences and answer them; nevertheless, there was a moment where the answers stopped to have any semantic logic, which unleashed a barrage of answers without any sense.  
In the cases where an artificial intelligence is designed to emulate natural language, the use of the heuristical method is impossible, since the language consists on semantic structures which can’t be represented syntactically (nor numerically) for their analysis, as the meaning is affected by the order and the selected words.   
To try and represent this in numerical variables isn’t ideal, as an ontology that can give each word a value and a syntactic meaning doesn’t exist; which makes the heuristic method harder to implement, as there are no values to work with.  
  
Besides this, we saw that not only heuristic knowledge is used on industries that use artificial intelligences in their processes, another common technique is Fuzzy Logic. The fuzzy logic control systems rely on the lack of precise information and making with decisions with that. Since there is a lack of information, heuristic knowledge can’t take part of the processes and make fuzzy logic systems work correctly. [16]   
In the Textile Industry we saw that fuzzy logic was also used, the function of these kind of systems is to classify the different kinds of materials and detection of litter and polluters on cotton. This is done because there are different kind of polluters that stick to cotton, so there is not a certain way to know how to identify them. That is one of the main uses in the textile industries of fuzzy logic. This system is so adaptable that a defect detection system based on fuzzy logic is being developed, which means that expert systems based on heuristic methods are not the only option for industries to work with artificial intelligence. [17]  
  
As we can see in these examples, the heuristic method can’t be applied in all the models or problems, as not all the problems can be modeled in a numeric fashion. Even if an ontology exists for almost all the fields, the artificial intelligence also requires an algorithm to work over said ontology. To try and apply the heuristic method in cases where the algorithms or the ontology are inappropriate, will cause the failure of the model or a wrong answer.

*Military:*

War has always been a space for innovation and creation in the technological field, provoking great advances in our daily life. But in the case of AI it’s different, its development has been mostly civil, and has adapted to the different fields. In the military field, its application has become the new “space race” of this era.

The artificial intelligence promises an improvement over data handling, bringing with it more precise logistics and planning. Because of this the AI is already a part of National Security, being implemented in cybersecurity to detect weak points, predict future attacks, analyze billions of data to detect suspicious activity, relocate soldiers in areas prone to conflict, etc.

The communication between the command center and the battlefield has always been key to achieve victory, the problem lays in the fact that the soldiers are not capable of communicating all the data on the field to the command center and the command center doesn’t have the capability nor the speed required to process all the data; this is the aim of the AI: data collection and processing.

In this case, the heuristic method has proven to be a great tool, as it receives a lot of numerical data from all the instruments carried by the soldiers that can be thoroughly processed in the central for it to reach a solution, which can be enacted by the commanding officers. Actually, the military don’t see a weapon in the AI, but a tool that will facilitate the data processing when it’s submitted to human control.

We have already seen the importance of communication, and data processing to achieve victory, but most of the armies in the world have bureaucratic processes that affect their ability to react. Also, the government have to be capable of creating a competent plan to respond an attack of crisis in the shortest possible time. This process can take time and resources, a perfect field for the implementation of an AI. This is the case of SIPE-2 (System for Interactive Planning and Execution), “a nonlinear AI planning system that plans at different levels of abstraction” (Wilkins, 1993). SIPE-2 generate plans for achieve given goals. The problems with SIPE-2, and most of the AI planning systems, can be divided into three: first, although AIs are capable of processing millions of data, it’s necessary to implement mechanism of relaxation; second, improve the heuristic to take into account human factors such as fatigue or traumas, for example: it’s easier and efficient to send the same group of soldier to different location in the same zone, but what if the group is fatigued; third, determined in advance the resources that AI can have and update if it’s necessary.

It’s funny to think that war, a purely human activity, is going to evolve into a conflict between robots, or so it seems to be. The main goal of robots in the battlefield, or at least today, is to save human lives, like the bomb diffuser or mine detector, or to gather information, such as scout robots. The implementation of AI in an individual robot may not have a great effect, but the creation of a network that communicates the units, the robots, with an AI, like the SIPE-2, could make a big difference. To achieve this network is necessary to a formidable infrastructure, as well as a competent AI, which as we have seen, is not perfect yet. I mean, the idea of an automated robot army is not yet possible, but it seems possible.

As we mentioned before, the heuristic in military AI have some problems: it’s necessary to constantly update the values in the heuristic, or make and AI that can adapt in every possible situation and takes into account human emotion and human limitation. Moreover, the infrastructure needed to have an automated army its huge; finally, it’s almost necessary the human supervision for the optimal function of the AI. Also, there are a problem related to the nature of the man his way of relating to others, as is the act of war, and make us rethink the purpose of the war.

Finally, the great advantages that the implementation of AI in the military field are undeniable. The main purpose its to expedite the processing and communication of data. The AI have the capacity to revel the needed data to make the best decision, it can relate a thousand of data and make a simulation of it, as well. In conclusion, we’re using the AI now just to processing data and generate option for the commanders, seems to be flawless. But, as it’s, AI is design to show data to a human commander, respond to human decision, and control human action in the battle field, I mean, is necessary the relation human-AI.

*Medical:*

The development of applications oriented to the medical field that implement an AI has been in constant growth since its development; this is partly because the heuristic scientific method is quite efficient to identify the symptoms form a great catalogue of diseases, and in this way, propose possible diagnostics.

Owing to the constant investigation and updates on all the diseases, it’s possible to determine the ontological principles needed to model an application that enables precise diagnosing. In this way, we can see that on one hand, the medical field is inherently scientific, and as such, is highly compatible with the used models for AI.

On the other hand, between the methods more frequently used in the development of these applications, we can find the analysis of photographic patterns, the reduction of problems to find an adequate diagnosis and the constant monitoring of the soulish values of the patient. Also, it must be cleared that in almost the totality of the cases, the development of these applications doesn’t aim to replace the specialist, as its scope is to serve only as a supporting tool for him [7].

After all that has been previously said about this field, it also must be cleared that there are other areas that have a more complex nature, and so, are less attached to the heuristic scientific method; as the determination of ontological principles or the reduction of problematics isn’t easily reached; this has its roots on the fact that the analysis of human behavior isn’t easy to reduce to a number of variables nor is it possible for it to be exactly replicated. Some of the areas that fall under this category would be the psychology and the psychiatry, for these cases, it’s necessary for the patient to undergo a more strict and personal analysis by a specialist [8].

Currently IBM is developing an application called Predictive mind that aims to diagnose and effectively predict the psychoses and psychopathies of a person with a single evaluation. [9] This has generated some controversy among the medical community, due to the fundamental absence of a specialist to make this type of assertions and questions whether it is correct to apply drugs under the criteria of an artificial intelligence of this type.

However, artificial intelligence technologies, such as IBM Watson, are used in oncological, pharmacological, and genomic studies to support diagnosis and create management plans for patients. Watson manages to create these plans by analyzing thousands of medical reports, patient records, clinical trials and medical journals.

Among the softwares offered by IBM are Watson for Clinical Trial Matching, which makes it easy for doctors to find lists of clinical trials for a quickly eligible patient, and helps clinical trial coordinators find qualified patients; IBM Watson for Oncology, which combines the deep experience of oncologists in cancer care and helps doctors consider individualized cancer treatments for their patients.[13]

Finally, it’s important to remark the importance of a heuristic scientific method that can simplify reality to a point where adequate solutions can be reached, for it to augment the number of effectively treated patients; but also, its worth noting that the application of heuristics different to the scientific one could be more adequate to model medical systems that can reach solutions of better quality.

Despite all of this, all fields such as medicine can be adapted to a certain degree, but when a subject of utmost importance is treated, such as health, it’s important to have the participation of a specialist in the final diagnosis.

Conclusion

It can be appreciated that in all the three fields, the use of the scientific heuristic method is extremely effective and has almost no flaws in all of the areas of common interest, such as data analysis or modelling of simple events; nevertheless, the method loses almost all of its effectiveness when the problem encompasses data that can’t be represented in a numerical fashion or that when it’s done in such a way, important aspects are lost for the calculations, such as the value of life.

In these cases, a heuristic befitting of the field was developed to improve the effectiveness of the process, which tended to be more efficient than its scientific counterpart; despite that, it was also seen that these new heuristics didn’t completely solve the problem, they just raised their success or usefulness rate compared to the scientific one.

Because of that, simply changing the heuristic proves to be insufficient to solve the most difficult problematics, depending on a human that can understand ethics and morals to take the last decision.

Therefore, it can be concluded that despite the boost in success rate that is presented by a new heuristic, it’s not enough to solve a problem, and therefore, the participation of a human in the problem solving will still be needed, until an AI is capable of understanding more subjective concepts.

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