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AEMac, Autonomous Evolution Machine: a Leap for Innovative Problem Solving

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Abstract:

This paper consists on the first steps of a very ambitious project. AEMac (Autonomous Evolution Machine) has been formulated to transition the innovation and problem solving responsibilities from human to computer machine. The framework for AEMac consists on the use of several AI tools such as Neural Network, Big Data tools and Deep Generative Design. Its logic sequence is presented in this paper and an example of its use is shown using a real use case in the mining industry estimating that the research and developing time would have been decreased around four times if AEMac's algorithm had been used with further benefits if used in its developed form. It is expected for this machine to reach new levels of innovation not only in engineering but also in medicine, law and education areas with the possibilities to expand into even further areas.

Keywords **—Artificial Intelligence, Neural Network, Innovation, Problem Solving**

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I. INTRODUCTION

Technology today is evolving at such a rapid pace that every year there are new innovative outbreaks. But is this our full potential? During the 20th century the genre of science fiction has developed and boomed in such memorable ways, that a large number of inventions could be considered inspired by such fictional works, but we must not forget that we have not reached all the expectations for the future. Let's remember for example in Kubrick´s film "2001: A Space Odyssey". It projected during the 60s that by the year 2000 humankind would be conducting outer space odysseys. Another example is Gale´s film "Back to the Future Part II" where it was assumed to have flying cars by the year 2015. It is a pity that despite the technological advances that have been made, society has not been able to fulfill that level of futuristic evolution that has been proposed in the past.

Creating such innovations can be challenging because of several reasons, such as employees not being empowered enough to take risks and try new ideas or people not being motivated enough to think more than the minimum required to operate at their current level. There are even deeper and more complex reasons such as the emotions we are bound to that could be counterproductive at the time of looking for optimal solutions and innovation, emotions such as envy, pride, competition between peers and lastly, let's not forget the most common reasons that could detain the person to work at 100% capacity, such as being tired, sick, hungry or just not sleeping well.

That is why AEMac (Autonomous Evolution Machine) has been formulated, to begin the transition of innovation and problem solving responsibilities from human to machine. AEMac is broadly organized in four parts. Starting with the use of "Failure Mandalas"[1] which is processed with "Neural Network"[2] in order to define the background of the failure and the triggering of it, followed by the "Contradiction Matrix"[3], implemented with "Machine Learning"[4] to select the inventive strategy, next the "121 Heuristics"[5] which is classified using "Big Data"[6] framework and processed using "Neural Network" in order to obtain the most optimized solution with the relevant patents to support the idea and lastly, the In-House production process using "Deep Generative Design"[7].

If the innovation obtained can be manufactured by tools like 3D printers, Open CNC and other Flexible Manufacturing Systems[8] that are connected to AEMac, then the innovation process is finished with the desired product in hand. On the contrary if the solution cannot be made In-House, then a series of instructions are given to implement the solution.

As it has been stated, each step is processed through Artificial Intelligence (AI), this way, many new outbreaking innovations and inventions would be created at an exponentially faster pace in all areas of work and science which will most likely create a new industrial and social revolution.

II. AEMAC

AEMac, a machine programmed in Python [9] (version 3.9 and above), enables the computer to learn from past problems along with their solutions in a way that allows it to decipher new solutions and innovations for future problems. AEMac processing is organized in four steps, as shown in the next sections.

A. Step 1: Failure Mandalas

Failure Mandalas is used as the first step of the algorithm in order to obtain the background of the failure, which allows the computer to know where the root of the problem is.

This section is programmed as "Neural Network" [2] using "TensorFlow" [10], an end-to-end open source platform for machine learning. The input layer is composed of the "Results of Failure", "Action of the Failure" and a few keywords to contextualize the problem. The former include key phrases such as:*specifications not met, poor hardware, poor software, mechanical event, thermo-fluid event, chemical phenomenon, electrical failure, degradation, abrasion, deformation, fracture damage, large-scale damage, external damage, damage to environment, harm to physical well-being, sickness, injury, death, mental trauma, economic loss, social loss, social systems failure, change in perception, results to happen, foreseeable results, unforeseeable results, near miss and potential hazard.* Additionally the "Action of the Failure" include key phrases such as:*poor planning, design misuse, hardware production, software production, operation use, maintenance/repair, transport/storage, disposal, nonobservance of procedure, erroneous operation, change in operation, emergency operation, careless movement, dangerous movement, movement during transition, movement during poor health, poor communication, self-protection, ethics violation, rule violation, change, emergency action and inaction.*

After the input layer has been completed, the pattern is formed through the hidden layers which are different categories of cause of failures. With the knowledge obtained from previous experiences, the algorithm reaches the output layer as shown in a summarized way in Figure 1, resulting in the "Cause of Failure" which could be one or more of the following phrases: *insufficient knowledge, disregard of tradition, insufficient understanding, insufficient precaution, fatigue or poor health, insufficient communication, disregard of procedure, narrow outlook, misunderstanding, misperception, misjudgment of situation, insufficient practice, insufficient prior research, insufficient environment study, change in environment, change in economic factors, poor authority structure, poor organization, poor strategy or concept, difference in culture, poor organizational culture, poor safety awareness, inflexible management structure, poor management, poor staff, occurrence of unknown phenomenon and occurrence of abnormal phenomenon.*

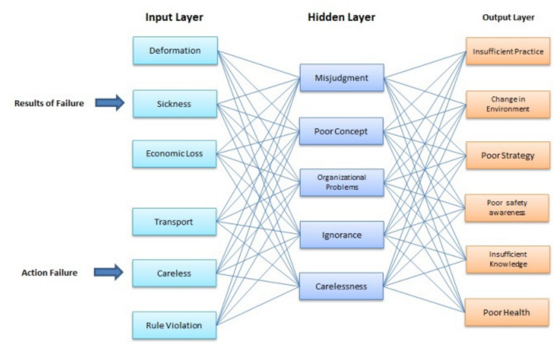

Fig 1 Summarized example on the information process through the Neuronal Network for the Failure Mandala

B. Step 2: Matrix Contradictions

Contradiction Matrix [3] is used as the second part of the algorithm in order to obtain the inventive strategy to apply for the desired solution or innovation. For this part of the algorithm, the open source machine learning library Scikit-learn [11] is used, which supports supervised and unsupervised learning using various tools such as model fitting, data preprocessing, model selection and evaluation.

This step consists of selecting the feature desired to improve and the feature desired to preserve, afterwards through the machine learning algorithm the Contradiction Matrix is processed, obtaining TRIZ´s inventive principles [12] which are the most adequate innovative strategies for the given situation. TRIZ inventive principles are the following:*segmentation, taking out, local quality, asymmetry, merging, universality, nested doll, anti-weight, preliminary anti-action, preliminary action, beforehand cushioning, equipotentiality, the other way round, spheroidality – curvature, dynamics, partial or excessive actions, another dimension, mechanical vibration, periodic action, continuity of useful action, skipping, "blessing in disguise", feedback, intermediary, self-service, copying, cheap short-living objects, mechanics substitution, pneumatics and hydraulics, flexible shells and thin films, porous materials, color changes, homogeneity, discarding and recovering, parameter changes, phase transitions, thermal expansion, strong oxidants, inert atmosphere and composite materials.*

Once the inventive principle has been selected (selected amount of principles may vary from 1-4 of them), begins the third process which is the use of Big Data tools [6] to cross-reference the inventive principles obtained with the 121 Heuristics, which results in explicit instructions to achieve a better solution or innovation.

Table I: Example of use of Matrix Contradiction. "Loss of substance" is the feature to improve and "Strength" is the feature to preserve. Inventive Principles 28, 31, 35 and 40 were obtained as the result.

Conradiction Mattrix	1. Weight of Moving Object	14. Strength	29. Productivity
8. Volume of stationary	-	9, 14, 15, 17	2, 10, 35, 37
23. Loss of substance	6, 23, 35, 40	28, 31, 35, 40	10, 23, 28, 35
Productivity	24, 26, 35, 37	10, 18, 28, 29	-

C. Step 3: 121 Heuristics

Heuristics play the role of explicit instructions which can be received as rules, strategies, principles or methods to increase the effectiveness of a problem resolution. During this step, the algorithm is organized using "Pydoop" [13], an open-source application programming interface (API) that can store and process the data obtained through artificial intelligence-enabled search engine "Semantic Scholar" [14] which was founded by Allen Institute for Artificial Intelligence.

During the Contradiction Matrix step, several Inventive Principles are obtained, for which those principles are then cross-referenced with 121 Heuristics to obtain their corresponding groups of Heuristics where only the most recurrent are chosen.

For each heuristic obtained, several patents are related and AEMac chooses the most adequate patent (or combination of patents). Lastly, the patent(s) obtained are adapted to the particular case including its failure background and triggering situation resulting in a new solution for the requested case.

D. Step 4: In-House Production

During the previous step a solution to a problem has been obtained and then its implementation has to follow. Depending on the type of solution, the implementation may be a series of instructions, a manual, blueprints or design concepts to produce. If the solution obtained is manufacturing a component, then Deep Generative Design [7] framework is used to generate numerous design options in an iterative manner to create the most adequate 3D CAD (Computer Aided Design). Once the 3D CAD is obtained, it is saved as an STL (Standard Triangle Language) file ready to be produced at the desired connected manufacturing system which may be an Open CNC, a 3D printer or any tool needed for the specific situation.

The basic algorithm has been presented in a general form because this same logic sequence can be implemented in many areas that need innovation, not only in engineering but can also be used in medicine, law and education with constant evolution in even more areas.

III. Example of Use of AEMac

In order to show the efficiency and correctness of this algorithm, several real cases have been compared using AEMac´s logic sequence to traditional problem-solving methods. For example, one of the real cases was the outdated design of the dump body for mining trucks.

The company "*Desarrollos Tecnológicos S.A*" has successfully created an innovative dump body for mining trucks. The improvement [15] [16] was spectacular and as a result Chile, known for importing technology, was able to export an engineering outbreak to foreign countries.

This innovation had four key features:

- The curved Dump Body, which reduces the stress concentration on it.
- The variable thickness of the body, which allows strengthening the most critical part created by the curve shaped body.
- The use of multiple composite material, which helps with impact absorption
- The use of lightening holes, which reduce weight, wear and energy consumption in general.

This solution has been engineered using "traditional" methods like trial and error, most likely improving each key feature individually and separately taking 20 years to develop [15].

A case study has been applied to this dump body system using TRIZ strategies to innovate and compare the results with "traditional engineering", where it was concluded by Dr.Sariego [16] that by using the Matrix Contradiction, only two of the four key features would have been obtained from the beginning of the design. It concluded that TRIZ is a necessity in the conceptual engineering stage because it shortens the developing process elevating its efficiency in time.

On the other hand, using AEMac, the developing party would begin by inputting the "Results of Failure", "Action of failure" and a few keywords to contextualize the situation. In this case it would be sentences like "mechanical event", "degradation" or "deformation" for results of failure, "operation use" or "careless movement" for action failure and "mining truck", "dump body", "mineral retrieval" as keywords.

After processing the Failure Mandala reaching a variety of cause of failures and responsible entities, it has decided that in any of those cases, because the health and safety of the operator is the top priority, the feature to preserve is "strength" while trying to improve the features "loss of substance" and "stationary volume". So the contradiction matrix [3] is processed with those features obtaining the following TRIZ's inventive principles: "Preliminary anti-action", "spheroidality-curvature", "another dimension", "dynamics", "parameter changes", "mechanics substitution", "porous materials" and "composite materials".

Once the inventive principles have been obtained, the third step is followed, which consists of cross-referencing the obtained principles with the 121 Heuristics [5]. Only the most recurrent groups are chosen which in this case are:

- Transformation of Materials
- Shape Transformation
- Quantitative transformation
- Structure transformation

For each Heuristic the most suitable patent has been chosen which are:

- Patent US695794B2 "Turbine blade attachment lightening holes" that suggests the idea of applying lightening holes
- Patent US6819037B2 "Display arrangement with reduced mechanical stress" which suggest the idea of using curved shapes to reduce stress concentration.
- Patent US9429103B2 "Variable fan nozzle with wall thickness distribution" suggesting the idea of thickening the wall thickness at the bottom of the body dump where the majority of weight will be concentrated.
- Patent US20150246502A1 "Impact Absorbing Composite Material" which suggests the use of composite materials for impact absorption.

After applying AEMac´s logic sequence, the four key features of the innovative dump body have been obtained with their relevant patents as examples, making it ready to proceed to the fourth and final step, the design of the new invention. Deep Generative Design would be used taking in consideration the four key features to create the 3D model and its STL file suited for the situation.

With the help of this machine, it would have been possible to develop all features at once from the beginning instead of following the old "one by one" and "trial and error" method. It is estimated that the research and development time would have been decreased around four times [17] if a person had applied AEMac's logic sequence as a strategy for problem solving, and the time that would be saved if the developed version of AEMac had been implemented is unimaginable.

IV. Popular Beliefs Against AI Technology and Possible Future Difficulties with AEMac Development

As any new technology emerges, it is normal to be sceptical and wary about the known and unknown dangers it may bring. It is not different with AI technology where certain opinions have raised with its use.

Next, some known disadvantages were found in Khanzode's publication [18] regarding artificial intelligence. Some counter arguments are shown against the disadvantages that were listed.

- **Some time it can be misused leading to mass scale destruction**: While this statement may be popular, it is more important to study further and deeper into AI to avoid this scenario.
- **Human jobs affected**: The ideal and long term goal of this investigation, is to create a society where it is not needed to work in order to live. The idea of having AeMac is to replace all productivity of human labour with intelligent machine work in order to liberate humanity into doing what they most want to do with their time.
- **Younger generation becomes lazy**: Evolution of technology aims to have a more relaxed lifestyle so it is natural for future generations to seem "lazy" compared to older generations. Just the same way it is not needed to hunt for food every day, run to deliver a message or smith our own tools.
- **Creativity is depend upon programmer**: AeMac is programmed to scan and process the largest amount of solutions, papers, research and past experiences possible independently of creativity.
- **Requires a lot of time and money**: A study from London suggests that 35% of jobs in the UK are at high risk of automation. [19] If technology really requires a lot of time and money then human jobs would not be replaced by machines.
- **Lack of human touch**: There is experimental evidence that people cannot differentiate AI-generated from human-written poetry. [20] Since AI has developed that much, it may not be lacking human touch.

Multiple positive points for the AI technology has been made, but applying and developing AEMac is not an easy task. One of the main difficulties is the skills shortage in the area. [21] In order to properly train AEMac to solve problems, some human training will be needed to be done beforehand. The second difficulty is the veracity of the experience used in the Big Data system. [22] Volume, velocity, variety and veracity are the four V's to keep in mind regarding the information needed to teach AEMac where many kinds of data quality problems may rise, like missing, duplicate, inaccurate, invalid, conflicting and stale data just to name a few.

V. CONCLUSIONS

In this paper the framework of Autonomous Evolution Machine (AEMac) has been presented in order to displace in a near future the innovation and problem solving responsibilities from human responsibility to a machine work to do. AEMac mostly utilizes AI tools such as neural Network, Big Data and Deep Generative Design in order to find and create solutions which is expected to reach new levels of innovations accelerating the progress of technology and possibly creating a new industrial and social revolution. A case study has been presented following AEMac's logic sequence in order to show the advantages of using a problem solving machine compared to "traditional engineering" demonstrating how much developing time and costs decreases.

It is taken into consideration, that as science and social aspects evolve, the output layer of the failure mandalas has to be updated according to the new technology available and during the 121 Heuristics step, as AEMac creates a new innovation it is thought to be added into the patent data base.

Currently AEMac is specialized in engineering and technical innovations. But based on the examples presented in Schuts's works [23] it was concluded that some limitations exist in the social sciences area, however with some modifications these problems could be resolved allowing a wider use of TRIZ. Which is why it is thought to be constantly evolving into other areas of work such as medicine, law and education.

Lastly, this project is currently on its first steps and open to any contributions and collaborations if the reader cultivates an interest on the topic.

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