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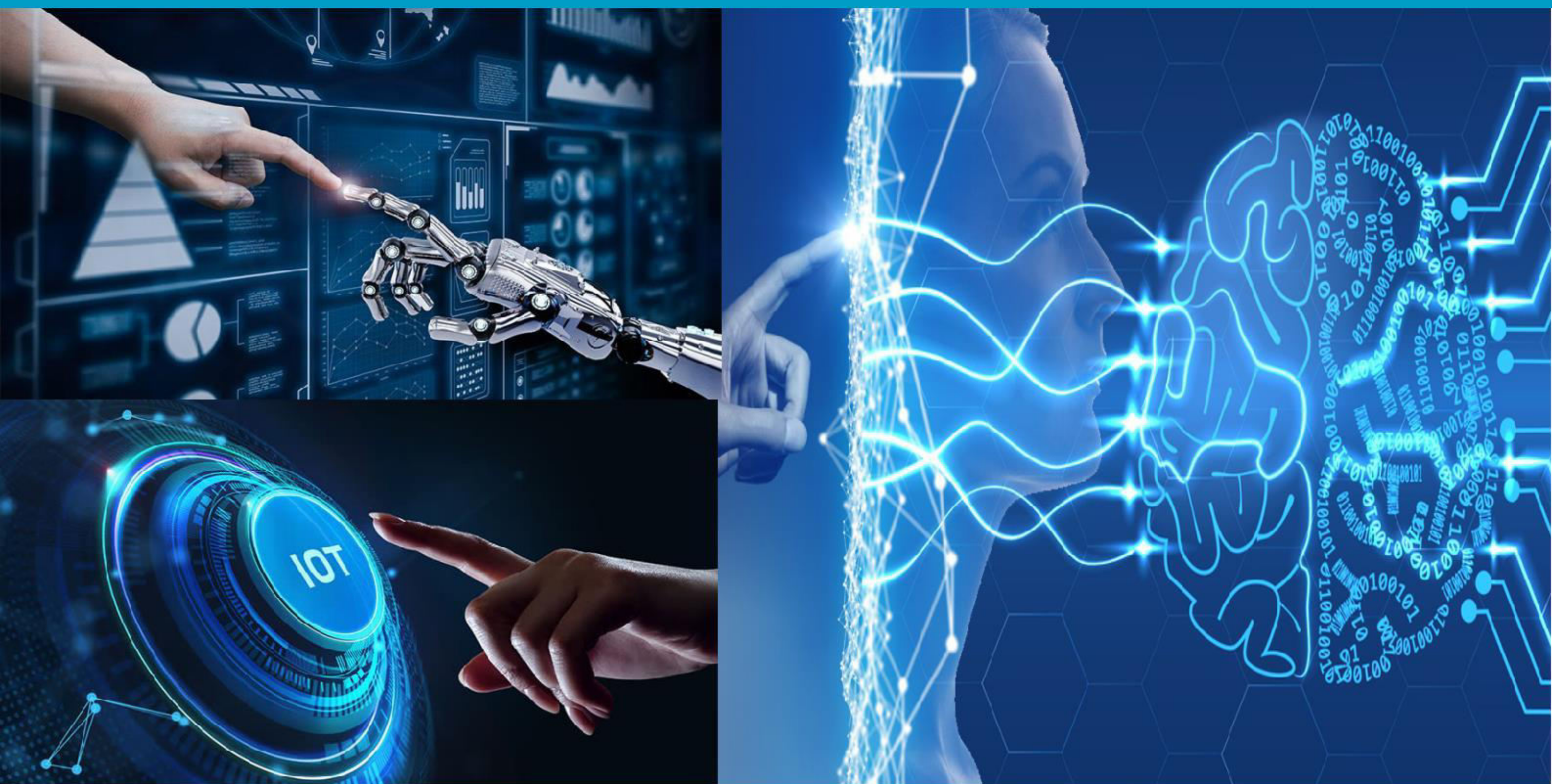

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Mathematics and Artificial Intelligence, Two Face of the Same Coin

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ABSTRACT: Unfortunately, in the learning of Mathematics and Computer Science, they appear often as disconnected areas, when they are indeed two necessary and complementary faces of the same coin .Either of them alone produces only ethereal structures, or routines and ad-hoc programs. For this reason, it would be preferable to study, progressively, from the lower educational levels, both disciplines as naturally linked. So, it will be overrated the pure mechanistic of only give informatics to usury level, as mere blind instructions, either too abstract pure mathematical constructs. Two side of the same coin, Mathematics –theory, rules and Structure.

AI; Applications intelligence and action .Mathematics is the language , AI is the conversation .Mathematics gives birth to AI and AI Challenges inspire new Mathematics

KEYWORDS: Mathematical Education; Computer Science; Artificial Intelligence; Game Theory; Graph Theory; **H**euristics; Mathematics.

I. INTRODUCTION TO MATHEMATICAL GAMES

1. Mathematics is the foundation of AI
Linear Algebra → Used in neural networks, image recognition, embeddings.
Calculus → Powers optimization (gradient descent, back propagation).
Probability & Statistics → Essential for predictions, uncertainty handling, Bayesian models.
Discrete Mathematics → Graph theory, logic, search algorithms.
Without mathematics, AI algorithms could not even be designed or trained.

2. **AI brings mathematics to life**
While math is abstract, AI applies it in the real world:
Self-driving cars use geometry + optimization.
Natural language processing uses linear algebra + probability.
Computer vision applies convolution (mathematical filters).
Reinforcement learning uses Markov decision processes (probability + linear algebra).
So, AI is like the "practical face" of math, where theories turn into technologies.

From remote times, the history of the human being is developed by a successive chain of steps and sometimes jumps, until the relative sophistication of the modern brain and its culture. We will describe here the evolution and application of certain games, being a useful tool not only as the "drosophila melanogaster fly" of AI, but also in Mathematical Education, as can be considering Chess and Go. Many great thinkers should study this difficult question: to reach the more efficient heuristic, i.e. strategies to win. Certainly, it will be a challenge for AI, and therefore, a mathematical problem, solved in the case of Chess, but it remain as a new challenge in the case of Go, as a many more complex game. For this reason, this appears as the new frontier of AI. So, the Go is waiting, and defy as an open mathematical problem to be solved, with new techniques, useful on another open problems.

Has been developed different programs to play it. But they are very far of the level of a great master. Because until now we haven´t an efficient heuristic evaluation function, to solve it. Not occurs as in the case of Chess, by the Alpha-Beta Pruning Method. But it does not appear as valid in this new situation. Therefore, we dispose of a new and very important challenge for the current AI research, a bench-work for future research.

Another interesting example, useful motivating the students, as connected with its diary life, can be the Sudoku puzzle. It has achieved worldwide popularity in recent times, and attracted great attention of the computational intelligence community. Sudoku is always considered as Satisfiability Problem or Constraint Satisfaction Problem.

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It is possible to focus on the essential graph structure underlying the Sudoku puzzle. First, by the formalization of Sudoku game as a graph. Then, a solving algorithm based on heuristic reasoning on the graph may be proposed. In order to evaluate the difficulty levels of puzzles, a quantitative measurement of the complexity level of Sudoku puzzles based on the graph structure and information theory may be proposed. Experimental results show that all the puzzles can be solved fast using heuristic reasoning, and that the proposed game complexity metrics can discriminate between difficulty levels of puzzles.

Origami is the art of paper folding. It also does have many educational benefits. Its connection with geometry is clear. But also the study of Origami and Mathematics may be considered into the field of Topology, although it may be more related with, or Graph Theory.

II. ABOUT ARTIFICIAL INTELLIGENCE

Among the things that AI needs to implement a representation are Categories, Objects, Properties, and Relations and so on. All they are connected to Mathematics, as well as being very adequate illustrative examples. For instance, showing Fuzzy Sets together with the usual Crisp or Classical Sets, which are a particular case of the previous; or Introducing concepts and strategies from Discrete Mathematics, as the convenient use of Graph Theory tools on many fields.

The problems in AI can be classified in two general types, Search Problems and Representation Problems. Then, we have Logics, Rules, Frames, Nets, as interconnected models and tools. All them are very mathematical topics.

The origin of the ideas about thinking machines, the mechanism through work the human brain, the possibility of mimic its behavior, if we produce some computational structure similar to neuron, or to neural system, their synopsis or connections between neurons, to produce Neural Networks... All this can appear with resonances of a Science

Fiction history, or perhaps a movie, but it is a real subject of study, and it is so from many years ago, and more in the last times.

The basic purpose of the A I will be to create an admissible model for the human. Its subject is, therefore, "pure form". We try to emulate the way of reasoning of a human brain. This must be in successive, approximating steps, but the attempts proceed always in this sense.

III. SEARCHING STRATEGIES

Between the Nets, the more recent studies to deal with Bayesian Nets, or Networks. Before than its apparition, the purpose was to obtain useful systems for medical diagnosis, by classical statistical techniques, such as the Bayes Rule. A Bayesian Net is represented as a pair (G, D), where G is a directed, acyclic and connected graph, and D will be a probability distribution, associated with random variables. Such distribution verifies the Property of Directional Separation, according to which the probability of a variable does not depends of their not descendant nodes.

The Inference in BNs consists in establish on the Net, for the known variables, their values, and for the unknown variables, their respective probabilities. The objective of BNs in Medicine is to find the probability of success with we can to give determined diagnosis, known certain symptoms. We need to work with the subsequent Hypotheses:

IV. EXCLUSIVITY, EXHAUSTIVELY AND CONDITIONAL INDEPENDENCE

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According the Exclusivity, two different diagnoses cannot be right at time. With the exhaustively, we suppose at our disposition all the possible diagnosis. And by the C I (acronym of Conditional Independence), the discoveries found must be mutually independents, to a certain diagnosis. The usual problem with such hypotheses will be their inadequacy to the real world. For this, it will be necessary to introduce Bayesian Networks.

In the searching process, we have two options: without information of the domain (Blind Search); and with information about of the domain (Heuristic Search). In the first case, we can elect, according the type of problem, between Search in extent and Search in depth.

There are other methods, obtained from the previous, such as Searching in Progressive Depth and Bidirectional Searching, both with names sufficiently allusive to its nature. Also we can found another method, in this case not

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derived, the General Search in Graphs. In such procedure, it is obvious the possibility of immediate translation to matrix expression, through their incidence matrices. All these methods joined to their algorithms.

Blind Search, or search without information of the domain, appears with the initial attempts to solve, by idealizations of the real world, playing problems, or the obtaining of automatic proofs.

V. SEARCHING IN EXTENT

We advance in the graph through levels. So, we obtain the lesser cost solution, if exists. Whereas, in the Depth Searching, we expand one link each time, from the root - node. If we reach a blind alley into the graph, we back until the nearest node and from this, we take one ramification in the graph. It is usual establish an exploration limit, or depth limit, fixing the maximal length of the path, from the root.

Heuristic Search, i.e. searching with knowledge of the domain. Initially, were usual to think that all the paths can be explored by the computer. But it is too optimist. Such exploration will be very difficult, because of phenomenon as "combinatorial explosion" of branching, when we expand. Its spatial and temporal complexity can advise us against its realization. For this, we need to select the more promising trajectories. In this way, we cannot obtain the best solution (optima), but an efficient approach to her.

VI. CONCLUSIONS

Not only may be these techniques very useful into the class-room, because through them Mathematics obtain a support on the aforementioned Games (Chess, Checkers, Stratego, Sudoku,), but also our students can be introduced in more subtle analyses, as may be the Prisoner's Dilemma. Also it will be disposable any information about games as Chess, Go, its Rules, Tricks, Hints, and so, in the Web pages, being as well possible to play with them. And we can obtain information of papers, web explanations, etc., about the history of such games, which will be very illustrative and motivating for the students. All these techniques has been implemented in the class-room with students of secondary level, increasing with them its interest in Mathematics and simultaneously, in TIC new technologies and its fundamental basis. Furthermore, with students of undergraduate university level, in studies of Mathematics and Computer Science, reaching a very positive reaction, which increments their interest and results.

As an example of educational practice for the classroom, we may dispose a group of people of reasonable size (from twenty to thirty students), of secondary level, or instead of undergraduate university level, in Mathematics or Computer Science.

We will give previously a basic introduction to the foundations to graphs and probability. For instance, we may shown this case of study: Bayesian Networks, as a directed, acyclic, connected graph, jointly with a probability distribution associated with each node, that express the mutual relationship between nodes representing states, by directed edges. It is possible to expose some very classical and illustrative examples, as may be the net ASIA, on infectious diseases, as tuberculosis. Or more simply, the well-known case of the wet grass, and if it is due to which today is raining, or perhaps it would be due to a water-sprinkler. Such examples are motivating not only to learn with more interest and motivation the graph theory tools, but also permits an elemental survey on the current research in AI, or more generally, in Computer Science.

By this new approach we defend, Computer Science occupies, partially and in a natural way, the role Physics and its problems have played as support of mathematical reasoning, a fact in the past two centuries (although Physics do not disappear from the view, being a necessary aid). We propose showing such Methods through the parallel study of Mathematics and Computer Science foundations. Other Computer Science subfields could be carriers of this method too, but perhaps AI is the current better choice, given its characteristics, which practically coincide with many mathematical techniques and objectives.

The creative learning permits to understand the development and practice of creativity. The possibility of founding new solutions is one specific characteristic of the creative process. It may consists in the art of formulate questions to obtain ideas, increasing capacities, defying the current conventionalism in the educative world. So, the benefits of such an innovative educative method must consist in a more progressive regard of Mathematical Education in modern times, with the final purpose of producing adaptive and creative minds, capable of solving new problems and challenges.

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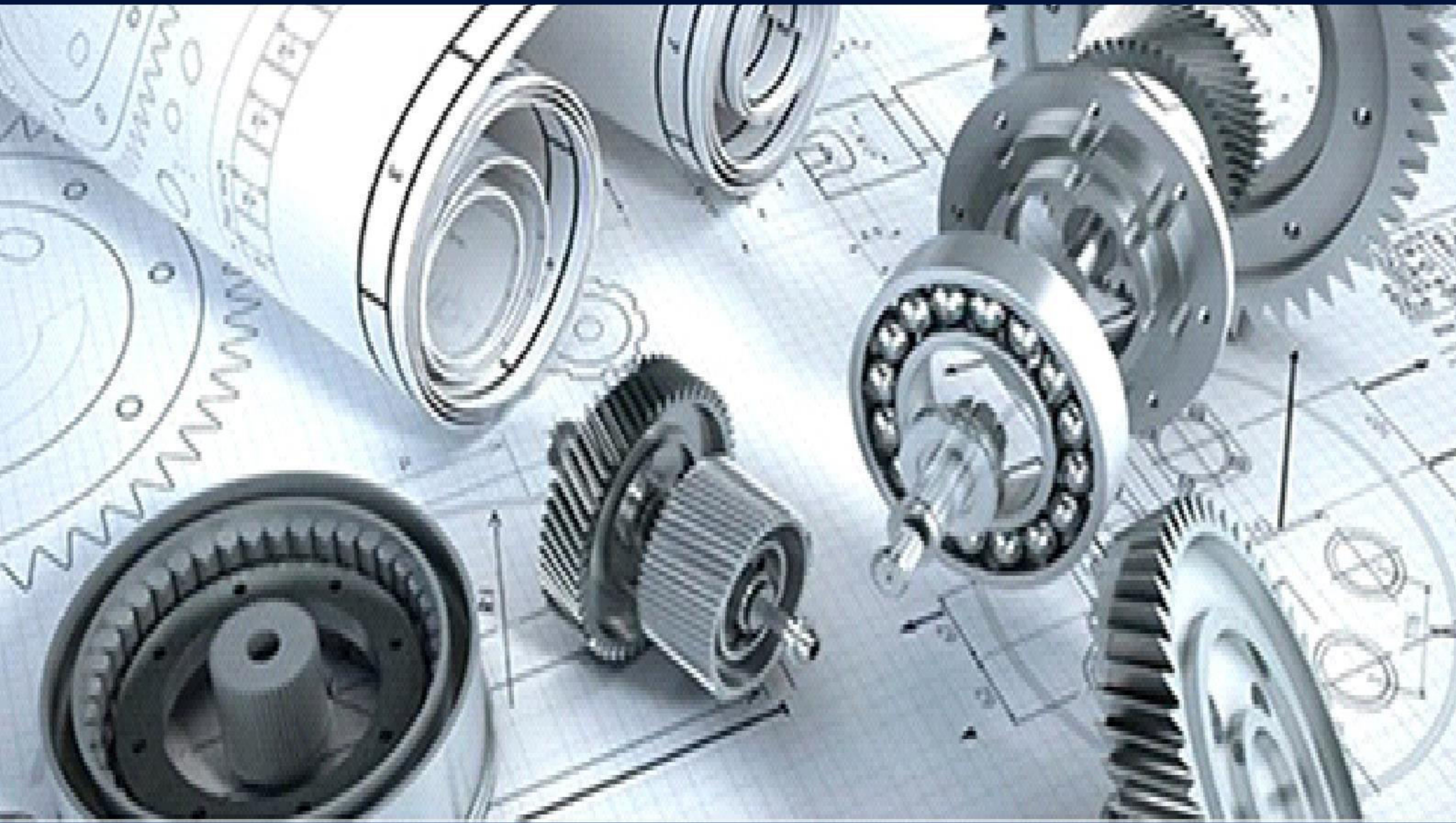

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