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Man-Machine Cohesiveness - A Philosophical Journey towards Innovations

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ABSTRACT: Man-machine cohesiveness presents a synthesis of the application of automata on one side with man's imagination as an innovative tool for criteria aggregation in the process of decision making on the other side. The integration may be made on crisp type or fuzzy type of set of problems [1]. The fundamental issue is that these integrations are able to model interaction among criteria with better flexibilities. This paper is concerned with the integration of widest class of automaton structures whose semantics are to be made compatible with the imagination of states with the criteria of new innovation. The application of these integrations in the multi-criteria decision making was first elaborated mainly in Japan and was applied there successfully in various fields such as design, reliability, evaluation of goods etc. [2]. One of the aims of this paper is to disseminate the technology of this integration in many industrial fields in order to provide a suitable strategy for innovation.

KEY WORDS: Multi-criteria decision making, Fuzzy logic, Crisp logic, Interactive criteria.

I. INTRODUCTION

An old English proverb, as it is known, is "Necessity is the mother of invention". The question that first arises by this proverb is what is "necessity" or how can "necessity" be defined. Furthermore, it must be understood how the necessities can lead people to invent something that will satisfy them through fulfilling all the requirements.

Before it is known what "necessity" is, the lacuna of the current situation must also be clearly understood. There should be a feeling that the current day situation is not enough to meet all the requirements. The feeling of "necessity" for something must arise first and then gradually it is required to develop an urge of getting that. For explicitly defining the demands it is required to have a proper support of language through which the demand can be expressed. In this consequence, Plato's theory can be recollected which proposed that the mind of the human infant is endowed with a "format" of a possible grammar (a theory of linguistic data), a method of constructing grammars based on the linguistic data to which the child is exposed, and a device that evaluates the relative simplicity of constructed grammars. The child's mind constructs a number of rules of its language and starts speaking. This effort ultimately gives birth to a modern language through which man can express their demands. After successfully defining the demand, man's next objective is to develop the stages through which they can develop their desired object – i.e. the stages of invention are required to be formulated.

Noam Chomsky worked on this philosophical concept and attempted to solve the linguistic version of Plato's problem which was presented in the "standard theory" of Aspects of the Theory of Syntax and subsequently in the late 1970's he revised the "standard theory" and developed the "extended standard theory".

History teaches us that many a times world has witnessed many inventions which were the demand of the hours and those changes took place through some series of stages. The statement can be justified if the examples of "Green Revolution" or the "Capitalist Movement" can be mentioned through which the economy shifted to the capital-intensive one from the years prevailing labour-intensive one. As a result the third-world countries witnessed a price-war. A prominent example may be the burgeoning market-share of China in the FMCG (Fast Moving Consumer Goods) sector.

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"Necessities" also induced the number system to get changed substantially. As the discovery of zero changed the entire scenario of the mathematics; likewise the invention of Binary number system brought a revolutionary change in the counting principles. Gradually, the fractions were recognized which took the shape of Floating point numbers. But its precision increase is still a demanding factor even today. The incidence of 1991 can be mentioned in this case. On February 25, 1991, during Gulf war, an American Patriot Missile battery in Dhahran, Saudi Arabia, failed to intercept an incoming Iraqi Scud Missile. The Scud struck an American army barracks and killed 28 soldiers. A report of the General Accounting Office, GAO/IMTEC-92-26, entitled Patriot Missile Defence: Software Problem Led to System Failure at Dhahran, Saudi Arabia reported on the cause of the failure. It turns out that the cause was an inaccurate calculation of the time since boot due to computer arithmetic errors.

There are numerous examples of errors that occurred because of incorrect formulation of strategies during innovations. On June 4, 1996, an unnamed Ariane 5 rocket launched by the European Space Agency exploded just forty seconds after lift-off. The rocket was on its first voyage, after a decade of development costing \$7 billion. A board of inquiry investigated the causes of the explosion and in two weeks issued a report. It turned out that the cause of the failure was a software error in the internal reference system. Specifically, a 64-bit floating-point number relating to the horizontal velocity of the rocket with respect to the platform was converted to a 16-bit signed integer. The number was larger than 32,768, the largest integer storable in a 16-bit signed integer and thus, the conversion failed.

So, it is evident that even today it has not been possible to provide a steady state which can satisfy all the requirements. - Albert Einstein once thus said "Reality is merely an illusion, albeit a very persistent one." The "necessities" change day by day - situations becoming more complicated and literally people are being forced to explore new strategies to combat the complications. Therefore, it is required to take initiatives to change the present state; otherwise it will persist and show high inertia to remain in the current state.

Therefore, it is required to develop some basic logical strategies which will be helpful to develop any further projects including turn-key projects and the obvious solution will come only through the precision in strategies.

It is indeed a real fact that scientific inventions of great significance have been linked with supporting a very prospective and desirable aspect of civilization. Today's scientific research would not have been developed or transitioned from lesser precision to higher precision as fast, if colossal efforts were not spent towards development of logical thinking. This is actually Man-machine cohesiveness, which is certainly achieved through better thinking power—in a philosophical way.

II. THE ADVENT OF AUTOMATA

The transition system, in technical terms, is known as AUTOMATA. Whenever a designing of protocol (rule) is required or an information system is to be developed or set of instructions which are known as Programs are to be executed or to design the probable solution of what the present situation is intended to do i.e. its characteristics, its behaviour and its message-passing style – it is required to use these special kinds of transition systems. Naturally, there is a variety of applications of automata in every sphere of life.

This can be explained with the help of the following game: In this game, a rule has been made beforehand in mind. A string of letters has been written. Only the letters A, B and C are written here. Then it is required to conclude whether each string follows the rule or not. The job is to guess the rule.

<u>Accepted</u>	<u>Rejected</u>
ABC	CBA
AAA	BBB
ABCABCABC	BCABCABCA
A	BBBBBBBBB
ACCCCCCCC	CAAAAAAAAAA

It can be guessed, from the above example that the rule is "The string must begin with A". Once the guess is made, it can be tested out by trying more examples.

Finding out this basic reasoning or logic or more precisely the mathematics is fundamental to any invention.

As it is known, Automata (more generally: transition systems) are the main modeling tools in Computer Science. Through the origin and development of programming language, it can definitely be observed that there is a great

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influence of our vernaculars on it. The first stage is to learn how a verbal communication (interface) can be established and understood among people (multiprocessing). In this practice, it may be noticed that human languages tend to be flexible as time elapses and become lucid. This trend gives birth to dialects (can be compared with CISC to RISC journey). Whenever a dialect is spoken by a large number of people i.e. accepted (understood) by the mass, it finds a suitable niche in the family of languages and achieve the status of a language (e.g. B, BCPL, ALGOL 68, C). Getting recognition means finding out an acceptor for it.

III. INFLUENCE OF AUTOMATA IN IMPROVING THE THOUGHT PROCESS:

Automata are systems consisting of states - some of them designated as initial and some as final and (usually) define transitions because of which the states may gradually approach towards finalisation. In classical automata theory, recognizable languages or sets of state-sequences have been investigated. Non-classical theory deals with several aspects, e.g. infinite sequences having non terminating behaviour, with dissimulation, or with different kinds of input objects, e.g. trees as input structures.

Noam Chomsky has defined a hierarchy of grammars which are known as types 0, 1, 2 and 3 [3]. It is convenient to represent sentences as a tree or graph to help expose the structure of the constituent parts. For example, the sentence "The boy ate a Chocolate" can be represented as a tree structure. Here the root node of the tree corresponds to the whole sentences and the constituent parts of S are subtrees where the left subtree is a Noun Phrase and the right subtree is a Verb Phrase. The leaf or the terminal nodes contain the terminal symbols.

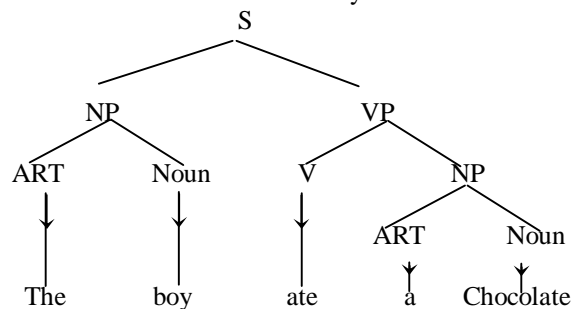


Fig. 1 A syntactic tree

Finite Automata deals with two fundamental issues. First, establishing a connection to logical (or "logic-like") expressions and second, discovering algebraic ideas and methods to solve typical problems. The model of a finite automaton itself may further be generalized, and use it for processing generalized inputs (i.e. not only finite jobs) and it is expected that generalization appreciates a better inheritance. This can be done in two different dimensions. One is to lift the constraint of finiteness and consider infinite inputs such as a run of a non-terminating procedure. In this case reaching some final state will not become the objective but rather the interest will be in ensuring stability, e.g. by-passing again and again through a certain state. The other is to consider (finite) inputs that are branching rather than being linearly ordered (i.e. letters follow one another). This second dimension leads to the tree automata and tree languages.

The primary motivation relies on the fact that trees model structured objects, which happen to be very frequent in computer science. The fundamental questions, those arise are related to the problem of generalization. They are as follows:

- Which techniques can be borrowed from the area of finite words?
- How can automata be constructed that describe the properties of trees?
- How the equivalent formalisms like regular expressions and logical formulas can be defined?
- Are there efficient algorithms for the fundamental problems (non-emptiness, equivalence and minimization of automata)?

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IV. THE APPLICATION OF TREE STRUCTURES

Trees arise naturally either in the form of structured data, or as terms, or as processes with branching behaviour. Some examples are provided to prove how this TREE structure helps in solving different types of problems arising in different paths of the life:

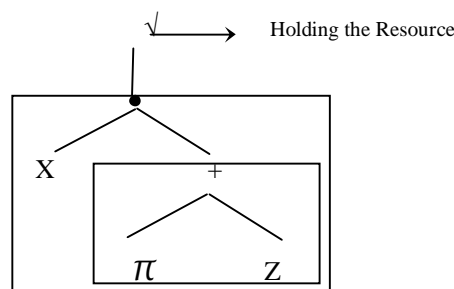


Fig. 2 The Tree corresponding to the term $\sqrt{X.(π+Z)}$

Automata can be approached for the automatic verification of finite-state programs as well as concurrent programs through model checking. The basic idea behind this approach is that for any temporal formulae, an automaton can be constructed that can accept precisely the computations which will satisfy the formulae [4]. The code snippet of WHILE-program is provided below to find out the GCD following the Euclidean algorithm. This program has been modeled by automata for verification.

```
{Input in x1, x2}
x3 := x1; x4 := x2;
WHILE x3 <> x4 DO
  IF x3 < x4
    THEN x4:= x4 - x3
    ELSE x3:= x3 - x4
  END
END
{the value of x3 is GCD(x1, x2)}
```

A formal definition of the WHILE-programs includes:

- A terminal alphabet: Σ_{digits}
- Non-terminal symbols:

S	for	<program>
W	for	<assignment of value>
V	for	<variable>
D	for	<decimal number>
Z	for	<positive digit>
F	for	<sequence of decimal digits>
B	for	<condition>
O	for	<comparison operator>
E	for	<arithmetic expression>

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- A grammar

S	→	W S; S IF B THEN S ELSE S END WHILE B DO S END
W	→	V:=E
V	→	D
	→	
D	→	0 Z ZF
Z	→	1 2 3 4 5 6 7 8 9
F	→	0 Z 0F ZF
B	→	EOE
O	→	= < > <> = <=>
E	→	D V (E+E) (E-E) (E.E)

According to this definition a possible syntax tree of the GCD-program looks as follows:

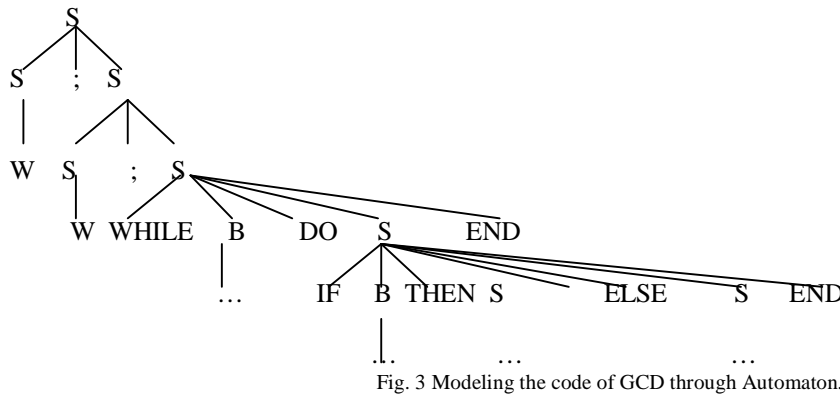


Fig. 3 Modeling the code of GCD through Automaton.

V. THE INFLUENCE OF AUTOMATA IN INDUSTRIES – FACTOR AUTOMATA FOR MUSIC IDENTIFICATION

Factor automata is denoted by $F(A)$ which is the deterministic automaton accepting the set of factors of a finite automata. A factor automaton is an efficient data structure for representing the full index of a set of strings. It is the minimal deterministic automaton representing the set of all factors of substrings of these strings [5][6][7].

Automatic identification of music has been the subject of several recent studies both in research and industries. Music identification systems attempt to match a recording of a few seconds to a large database of songs. The application of factor automata for music identification has many applications including end-user content-based search, radio broadcast monitoring by recording labels and copyrighted material detection by audio and video content providers such as YouTube [5].

Let a finite alphabet be denoted by Σ . For a symbol $a \in \Sigma$, the notations a^* , a^+ and a^n denote a repeated zero or more times, one or more times and n times respectively. Similarly, Σ^* , Σ^+ and Σ^n denote zero or more, one or more and n consecutive symbols from Σ respectively. The length of a string $x \in \Sigma^*$ in number of symbols is denoted by $|x|$. The symbol ϵ represents the empty string.

VI. RECOGNITION TRANSDUCER

The music identification task is to find the song(s) from a set of songs S (song database) that contain a query song snippet x . In speech recognition it is common to use the Viterbi algorithm [5] by the transducer in order to decode the test-audio after specifying the mapping of phoneme sequence to word sequences through a weighted finite-state transducer [8]. For single song identification, the recognition transducer must map any sequence of music phonemes appearing in the transcriptions found in the final iteration of training to the corresponding song identifiers [9][10]. Let Σ denote the set of music phonemes and let the set of music phoneme sequences describing m songs be

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$U = \{x_1, x_2, \dots, x_m\}$, $x_i \in \Sigma^*$ for $i \in \{1, 2, \dots, m\}$. A factor or substring of a sequence $x_i \in \Sigma^*$ is a sequence of consecutive phonemes appearing in x . Thus, y is a factor of x iff there exists $u, v \in \Sigma^*$ such that $x = uyv$.

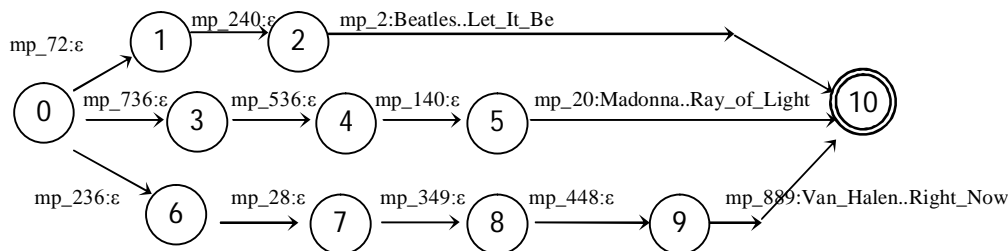


Fig. 4 Finite-state transducer T_0 mapping each song to its identifier. mp_x stands for music phoneme number x .

Let T_0 be the transducer mapping phoneme sequences to song identifiers before determinization and minimization. Fig. 4 shows T_0 when U is reduced to 3 short songs. Let A be the acceptor obtained by omitting the output labels of T_0 . Intuitively, in order to accept all factors of A , it is required to accept all the symbol sequences labeling any path between any pair of vertices in A . It can be accomplished by creating ‘shortcut’ ϵ transitions from the initial state of A to all other states, making all states final and applying ϵ removal, determinization and minimization to yield an efficient acceptor.

VII. AUTOMATA FOR THE ANALYZING THE STRUCTURE OF A DIAMOND

The network structure of Diamond resembles the structure of graph and thus can be viewed through Automata. Diamond is made up of repeating units of carbon atoms joined to four other carbon atoms via the strongest chemical linkage, covalent bonds. Each carbon atom is in a rigid tetrahedral network where it is equidistant from its neighbouring carbon atoms. The structural unit of diamond consists of 8 atoms, fundamentally arranged in a cube. This network is very stable and rigid, which is why diamonds are so very hard and have a high melting point.

At a very high temperature ($\cong 1073K$) and high pressure the diamond is decomposed to Carbon-di-oxide. Obeying some predefined micro and macro conditions, the nodes start exploring and are released from the existing structure. This way the nodes are transited from one state to another state. The transition function is determined by the inputs from the outside world; e.g. heat and pressure. These parameters behave like the inducing factors transition. How the above mentioned parameters influence the nodes are determined by their corresponding domain; i.e. the resources or chemical properties held by the nodes (e.g. Carbon, in example). The bond structure which depicts a graph represents cohesiveness and the relations defined through the edges. The cyclic property of a graph further ensures that there may not be any confirmed starting node, as it is observed that the structure may explode at any node and thus establishing that particular node as the start node. Thereafter, it keeps on decomposing, i.e. the cyclic structure is gradually decomposed in to an acyclic structure, i.e. a tree.

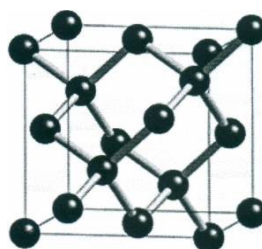


Fig. 5 Structure of diamond

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Before starting the exploration, when the structure was cyclic, there was a deciding factor as to which child will be explored next - i.e. the Left or Right with respect to the Head node. The Decision Parameter through which the very next child that is to be explored, is governed by the Locality of Reference of Kinetic Energy. This decision parameter induces the exploration in one direction only and thus, removes the confusion of availing more than one possibility. This incidence may be compared with the known transition i.e. a transition from NFA to DFA.

VIII. CONCLUSION

Automata, in its various forms, can be identified as the stepping stone of innovations. It not only provides a proper strategy of production rules but also provides the concept of "Memory" as well. Today whatever concept or machines are built or whatever improvement in precision may be sought in the generations coming next, it is true that all these innovations must rely on the facts and figures of the "history". In this context, in recent years, a term called Memory span has been coined which defines the amount of past input and output information needed to memorize in order to determine future behaviour. Therefore, man-machine cohesiveness can definitely pave the philosophical way of achieving a better tomorrow through determining the unique output sequence(s) where the initial state will be completely deterministic or to be made deterministic and their corresponding input sequences are also completely known or to be known in due course of time.

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