PART B—INVITED LECTURES

Polynomial Solvability of 3-SAT

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Computationally hard problems were formulated as NP-Complete problems by S.A. Cook in late 1960's. 3-SAT has been one of the first NP-Complete problems. Subsequently, for last four decades, while 2-SAT is well-known to be solvable in polynomial (in fact linear) time, , it was widely believed that 3-SAT does not have polynomial algorithm. In this talk, we give our recent result that 3-SAT is also solvable in polynomial time. To describe our approach for polynomial solvability of 3-SAT, we first study a few polynomial algorithmic formulations for 2-SAT. Our approach for the most surprising result that 3-SAT is also solvable in polynomial time relies on these algorithmic formulations.

For a 2-CNF formula with k clauses, we generate 2*k conditionals (consisting of a 2-Clause represented as a conditional as well as its contrapositive conditional), and we introduce the notion of a pair consisting of an antecedent set (of literals) as well as consequent set (of literals) to represent each conditional. For a 2-CNF formula with k clauses, we start with 2*k such pairs. To analyze the satisfiability of a give 2-SAT formula, two main algorithmic formulations we introduce are: (i) TruthAnalysis-2SAT( ), together with UpdatePairs( ), and, (ii) analysis of lists (of consequent literals discovered). We point out that repeated application (closure) of properties of (i) contrapositivity, as well as (ii) transitivity, are important for polynomial solvability of 2-SAT.

Later, to adopt our 2-SAT approach for polynomial solvability of 3-SAT, we introduce the notion of "context". For a 3-CNF formula with k clauses, we start with 3*k pairs and generate one context for each pair; thus, we start with 3*k such contexts. We construct one 2-SAT problem for analyzing each context. This approach results in the most surprising result that 3-SAT is also solvable in polynomial time. Our algorithmic formulation for 3-SAT is given in two parts: (i) TruthAnalysis( ), and, (ii) UpdatePairs( ). Our step 2 of TruthAnalysis( ) includes slightly different way of solving 2-SAT, namely, the analysis of lists (of consequent literals discovered). We also point out that repeated application of (closure with reference to) properties of (i) contrapositivity, (ii) transitivity, and (iii) context extension analysis (that we formulated as the 2-SAT problem), are important for polynomial solvability of 3-SAT. Using simplified analysis, we obtain a bound of O(k3n3) set operations for our polynomial algorithm for 3-SAT. This bound demonstrates the polynomial solvability of 3-SAT.

Hybrid Intelligent Systems for Context-aware Services

Sung-Bae Cho

In the era of digital convergence new personal business assistant and entertainment equipment have appeared with many technologies such as wireless voice/data communication, digital camera, and multi-media players. As the devices get complicated, we are in need of putting together available AI techniques to cope with the constraints and realize intelligent services in full scale.

Since 1995 the Soft Computing Research Laboratory has been exploiting the sophisticated technologies such as neural networks, evolutionary computation, fuzzy systems, and Bayesian networks, and developing the systems to solve complex real-world problems effectively by integrating them with the conventional AI technologies. In this talk, I will present the general introduction on the researches and some of the projects that are pursuing advances in AI. Some of the highlighted projects are as follows: artificial secretary for conversational assistant, context inference and learning for intelligent robots, mobile intelligence for summarizing user's daily life with cartoons and mobile life browser.

Fuzzy logic *via* Computing With Words (CW): A Case study

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In the real world, uncertainty is a pervasive phenomenon. Much of the information on which decisions are based is uncertain. In everyday life we take many decisions using words but paradoxically in science and technology *"numbers"* are respected and not *"words*".!. Why always compute with numbers and why not with words? Humans have a remarkable capability to make rational decisions based on information which is uncertain, imprecise and/or incomplete. Formalization of this capability, at least to some degree, is a challenge that is hard to meet. In this quest , Professor Lotfi Zadeh, the father of fuzzy logic at the University of California Berkeley USA the living legend and recently coined a concept - *Computing With Words (CW*) which will, in times to come, have an important position in decision research.

Computing with words fuzzy deals with the following four rational: Don't need rational: Crawling of a child, Don't know rational: Driving in a busy traffic , 3 Can't define rational: Risk, Intelligence, WQ/AQ, and Can't solve rational: Complex formulation. The key points of CW are: *CW is closely related to computation with natural language; CW is related to granular computing, Gr C, and CW is unrelated to natural language processing.* The salient points of two rationale of CW methodology used in fuzzy logic are : Words are good enough.; True numbers are known but there is a tolerance for imprecision which can be exploited by employing words in place of numbers, aiming at a reduction in cost and achieving simplicity. Use of words is advantageous; Linguistic summarization. and words are used to summarize numerical information. Precisiation and its variants plays significant role in two level complexity based CW methodology. Fuzzy logic needs CW but CW may or may not need fuzzy logic.

Fuzzy logic has come of age. During much of its early history, fuzzy logic has been an object of skepticism and derision, in part because fuzzy is a word which is usually used in a pejorative sense. Today, fuzzy logic is used in a wide variety of products and systems ranging from cameras, home appliances, medical instrumentation and automobiles to elevators, industrial control, subways, fraud detection and traffic control systems. And yet, there are still many misconceptions about fuzzy logic.

We will discuss CW methodology and related issues at length with a case study: Environmental friendly and energy efficient Fuzzy logic based air conditioner.

Software Racing Towards Mindware

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1. Inventions in the 19th century and the first half of the 20th centuries extended man's physical power enormously taking man to other planets and launching exploratory laboratories into space.

2. The second half of the 20th century and the first decade following it have been seeing inventions that are extending the brain and mind power of man which may lead to the evolution of a super -mind and superman as envisioned by the sage, Aurobindo Ghosh .

3. Computers & software as parts of Information Technology and Optical Fiber transmission and Communications Satellites are linking the world's hundreds of millions of websites which are store houses of all the information and knowledge that mankind has been accumulating through ages.

4. The Internet is a super -brain network and storage and software are helping even the outsourcing of memory and logic and discovery. Search engines are bringing the most relevant and research information in seconds from eh global store-houses, the web-sites. This will profoundly affect the evolution of brain and capability of mind.