Applied Logic Lab:
Draft-1

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1 Applied Logic Lab: Draft-1

The applied Logic lab is concerned with development of useful tools and other applications based on the ideas of philosophical and the mathematical logic. It attempts to understand the nature and scope of reasoning as used in the daily discourse. The purpose of the lab is to attract the like minded people and bring them to a common platform where one can discuss foundational issues while exercising reasoning and argumentation in the respective disciplines.

1.1 Background

For centuries mathematics has been seen as the one area of human endeavor in which it is possible to discover irrefutable, timeless truths. Indeed, theorems proved by Euclid are just as true today as they were when first written down more than 2000 years ago. But, 20th century witnessed at least three crises that shook the foundations on which the certainty of mathematics seems to rest. One is Godel's incompleteness theorem(1930), four-color theorem, the problem of finite simple groups. The first is concerned with the unprovability where any rich sufficiently axiom system is guaranteed to possess statements that could not be proved or disproved with in the system. The problem of four-color is concerned with the computational tractability, whose proof necessitate lengthy and intensive computational calculations. These three crises could be hinting that the currently dominant Platonic conception of mathematics is inadequate. As Davies remarks:

> [These] crises may simply be the analogy of realizing that human beings will never be able to construct buildings a thousand kilometers high and that imagining what such buildings might "really" be like is simply indulging in fantasies.

During the past twenty five years there has been extensive, continuous, and growing interaction between logic and computer science, Economics(Game theory), Natural sciences (Quantum Logic). The interaction is more intensive with respect to computer science and AI. It is evident from the fact that in many respects, logic provides computer science with both a unifying foundational framework and a tool for modeling. In fact, logic has been called "the calculus of computer science". Tools of formal logic are being widely used in the verification and design of *programs*. For a curious reader we refer to an important book.[1] The ability to describe an economic model verbally, graphically using the tools of logic will make our economic life a lot easier.

An electrical engineer may be looking for alternative ways of explaining the input/output behavior and look for for some interesting logical alternatives. This will lad to the development of efficient logical design of circuits. Physicists might be interested in understanding behaviour of particles in the subatomic particles and in the macroscopic objects such as the study of stars. Either he will be engaged in either deterministic or indeterministic framework Mechanical engineers might be intrigued to understand how the fuzzy washing machines work? What is the underlying logic of Fuzzy machines? Answer to these questions would enable them to develop

[1] A. Nerode and R. Shore: Logic for Applications, Springer, 1997.

more and more efficient systems. Finally, a curious mathematician might be interested in answering the questions which raises debates as to what makes mathematics certain?. Less recently, there has been increase in attention in dealing with the role of logic in games and economics. However, the growth of literature in the area ”logic for Computer science is large, where the knowledge of algorithms in developing some tools such as **social software**. It is based on *social procedures* simulated appropriately on a machine that exhibits intelligent behavior. So an underlying logic in a given phenomena (in science), the idea of valid principles, logical consequence(what follows from what) are the main topics of study of Logic and its corresponding tools.

It is far from clear what is meant by Logic or what should be meant by it. It is nevertheless reasonable to identify logic as a study of inferences and inferential relations. The obvious practical use of logic is to help us to reason well, and to draw reasonably good inferences. The subject matter of Logic is the study of logical connectives $\vee$, $\wedge$, $\rightarrow$, $\leftrightarrow$, $\neg$. Interestingly, we cannot utter or express few meaningful sentences without invoking these connectives. We can view logic as a language which consists of syntax and semantics and the interplay between the two. We need logic to distinguish valid from invalid arguments. Principles of logic allows us to prove some theorems in mathematics. What I intend to do in the logic lab is as follows:

2 Knowledge representation and reasoning(KRRU)

Why Knowledge representation relevant to AI systems? Unlike other representations, models based on KR aims to model behavior of sufficiently complex systems. It involves modeling beliefs, desires, goals, intentions and hopes etc. From the knowledge representation perspective, there are two levels of representing the knowledge based system. One is knowledge level, where we deal with expressive adequacy a representation language and the characteristics of its entailment relation and on the other hand, we have symbolic level, where we ask questions about the computational architecture and the properties of data structures and reasoning procedures.

One of the foremost things in developing intelligent systems is to represent them and reason them. It is motivated by the knowledge representation hypothesis by Herbert Simon and Brian Smith.

> Formal symbol manipulation is both a necessary and sufficient mechanism for general intelligent behaviour (Simon, 1957)
>
> Any mechanically embodied intelligent process will be comprised of structural ingredients that
>
> 1. we as external observers naturally take to represent a propositional account of the knowledge that overall process exhibits, and
>
> 2. independent of such external semantic attribution, play a formal but causal and

essential role in engendering the behaviour that manifests that knowledge.

It combines expertise in knowledge, reasoning with knowledge, intelligent database systems, semantic networks, and conceptual modelling. Such systems are characterized by rich semantic features and are computationally tractable.

The objective here is besides conducting theoretical work on the above issues, ie KRRU, we carry out applied research work. There are number of application domains including, Semantic web, Multi-agent systems, Consumer choice, E-commerce and Information retrieval. Work in these domains has a strong inter disciplinary character, since it includes the aspect of understanding the respective domain and modeling it through appropriate characterization.

2.1 Tentative Research Projects

1. Belief revision in semantic web environment
2. Modelling preference using the logic of epistemic entrenchment ranking of beliefs.
3. Trust and the dynamics of belief change
4. causal models and Bayesian Networks in analysis of counterfactuals.

3 Logic in Schools

It goes without saying that *logic* play an essential role in the development of career of children and adults at various schools and colleges. Children should be able to distinguish valid arguments from invalid and should be sufficiently acquainted with principles of logic to understand the intricacies of *reasoning* involved in the natural and social sciences. It helps them in understanding and solving the puzzles and problems. For instance, starting from the choosing the problem to proving the hypotheses, they undergo a logical sequence. This has a clear bearing on the principles of logic. Logic gives more *rigor* to the arguments.

Here, the main objective is what to teach when logic is introduced in the school curiculam? What makes it a different exercises when compared to problem solving(Polya). Association of symbolic logic came up with guidelines as to what to teach as a subject matter of logic, at various levels. At the university level WinKE software has been effectively used in the teaching of Logic.[2]

[2]http://staff.science.uva.nl/ ulle/WinKE/papers.html

4 Logic and Psychology

Here, we are concerned with testing logical models using psychological tools(experimentation, case studies). The questions concerns us are - Does logic work? Do we actually reason the way it is known through logical principles? Until 19th century, two fields of logic and psychology were closely tied to each other. What changed the situation was the growing discipline of experimental Psychology and the symbolic logic as advanced by Boole and DeMorgan.

Today, as Jhon MacNamara has put it, "logicians and psychologists generally behave like men and women in an orthodox synagogue. Each group knows about the other, but it is proper from that each should ignore the other".[3]

The return to limited psychlogism is the root of a host of recent developments in several different areas of theoretical AI. Perhaps the best example is the nonmonotic reasoning, which have received surprising amount of attention in the recent years. Automated theorem proving (the science of programming computers to prove mathematical theorems) was once thought of as a strong hold of deduction. What the deduction captures only small part of what mathematicians do when they prove theorems. For example, after many years of productive research in automated theorem proving, Alan Bundy (1991) has come to the conclusion that

> Logic is not enough to understand reasoning. It provides only a low-level, step by step understanding, whereas a high level, strategic understanding is also required. [4]

Here, we are interested in three activities:

- How belief revision models actually work? What are the cognitive constraints when we implement belief revision models?
- How actually we reason? [5].
- Behaviour of an agent in a finite game and come up with better strategies which are implementable.

[3]MacNmara(1986) A border dispute: The place of Logic in Psychology, MIT Press, Cambridge MA.

[4]Bundy, alan (1991) A sicience of reasonng, in Computational Logic edited by Lasser and Plotkin, MIT press, Cambrifge MA.

[5]Following Jhonson-Laird's mental model