

## Logic in India—Editorial Introduction

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### 1 History of Indian Logic

In the words of David B. Zilberman,

The most remarkable feature of Indian formal logic (as it was reflected by the most advanced system of Indian logic, by Navya–Nyāya) is clearly a close connection of a logical formalism to a linguistic material . . . A common characteristic of Indian knowledge on all stages of its existence was a consistent intentionalism, whereas European logic was still a predominantly extentional one. Important properties appeared to be also a utilization of non-quantum formalized expressions, presence of a complicated theory relations, and a unique theory of multi-level abstraction. (...) According to Bochenski, Indian logic can be of interest to Western logicians because it was ‘initiated on different foundations’. [13, p. 119], [3, p. 517]

Logic arose in ancient India from the art of conducting philosophical debate, prevalent probably as early as the time of the Buddha in the sixth century BCE

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but became more systematic and methodical in the subsequent four hundred years. By the second century BCE, there were several manuals for formal debates, perhaps the most systematic of them being *Nyāyasūtras* of Aksapāda Gautama. Aksapāda defined a method of philosophical argumentation called the *nyāya* method. It starts with an initial doubt, as to whether  $p$  or not- $p$  is the case, and ends with a decision that  $p$ , or not- $p$  as the case may be. There are five ‘limbs’ in a structured reasoning: the statement of the thesis, the statement of reason or evidence, the citation of an example, showing of the thesis as a case that belongs to the general one and the assertion of the thesis as proven. The Buddhist logicians argued that the first two or three of these were relevant. In any case, the discussion was on articulation of inference schemata.

There was a continuing tradition of logic and the Jaina logicians were concerned with epistemological questions. Perhaps the most important ‘school’ in the long list of logician communities was that of the Navya–Nyaya founded in the 13th century CE by the philosopher Gangeśa. His *Tattvacintamani* (“Thought-Jewel of Reality”) dealt with logic, some set theory, and especially epistemology. This school developed a sophisticated idiom for analysing inference, one that has been refined over centuries and is still used by scholars.

The systems of Indian logic are a topic of research and debate to this day, and a community of scholars undertake studies, meet periodically and discuss their observations.

## 2 Logic in India in the Twentieth Century

The widespread influence of the eminent philosopher Sarvepalli Radhakrishnan on Indian schools of philosophy meant that many modern Indian philosophers focussed on spiritualism in Indian thought rather than formal logic. While a few did take up studies on formal semantics, modern developments in mathematical logic were largely unfluent in Indian studies. Modal logic and incompleteness phenomena attracted some Indian mathematicians [11, 12] but only in the last two or three decades of the twentieth century did research in logic come into its own in India.

From the perspective of philosophical logic, the work of Frege and Quine, and the role of formalization intrigued many philosophers, especially in relation to similar notions in Indian systems of logic. The influence of thinkers such as Wittgenstein was also considerable. Towards the end of the century, notions from non-classical logics such as non-monotonicity and imprecision in truth, especially in relation to formal epistemology, attracted the attention of many researchers [4, 5].

On the other hand, mathematical studies in logic were few. Algebraic logic, inspired by the work of Helena Rasiowa [9] offered a home for some mathematicians [2]. However, it was the advent of computer science that gave a tremendous fillip to logic studies in India. Studies in logics of programs, programming language semantics, temporal logics and artificial intelligence

led to interest in mathematical logic per se, and soon, with the exception of a handful in Mathematics and Philosophy, logic became a subject of teaching and research in the computer science departments in India. A newly emergent and confident theoretical computer science community sought to build bridges with mathematicians in the areas of combinatorics, graph theory and number theory, and with logicians in the areas of model theory and proof theory, bringing algorithmic and complexity theoretic notions into the tools [7, 8, 10]

### 3 The Association for Logic in India

It was in such a background that **ALI**, the Association for Logic in India (see <http://ali.cmi.ac.in/>) was formed in 2007, with the basic aim of building a logic community in India, promoting research and education in logic and its applications. A foundation for this had been provided by the annual meetings of the Calcutta Logic Circle (a regular feature for two decades), the first two editions of the Indian Conference on Logic and its Applications (ICLA) at IIT Bombay (January 2005 and January 2007) and the International Conference on Logic, Navya–Nyāya and Applications at Kolkata in January 2007. By now the Indian Conference on Logic and its Applications (ICLA) is biennial, taking place in the January of odd years, and the two-week long Indian School on Logic and its Applications (ISLA) is biennial as well, taking place in the January of even years.

**ICLA** The biennial Indian Conference on Logic and its Applications (ICLA) is a forum for bringing together researchers from a wide variety of fields that formal logic plays a significant role in, along with mathematicians, philosophers and logicians studying foundations of formal logic in itself. The fourth conference was held at Delhi University, in January 2011, and the proceedings published as LNCS 6521 in the FoLLI series [1]. It had as a special feature the inclusion of studies in systems of logic in the Indian tradition, and historical research on logic.

**ISLA** The Indian School on Logic and Applications (ISLA) is a biennial event as well. The previous editions of the school were held in IIT Bombay (2006), IIT Kanpur (2008), and University of Hyderabad (2010), and an upcoming ISLA is at Manipal University (2012). The objective is to present before graduate students and researchers in India some basics as well as active research areas in logic. The School typically attracts students and teachers from mathematics, philosophy and computer science departments. The school adopts a dual format: the mornings will consist of introductory courses on fundamental aspects of logic, by eminent researchers in the area. The afternoons have workshops, which can be of the nature of advanced tutorials, or presentations on research areas, in different aspects of logic and applications.

## 4 Contents

This special issue on Logic in India aims to provide a sampler of work from both traditions, that of Indian logic, as well as work from logicians active in mathematics and computer science in India.

‘*Possible Ideas of Necessity in Indian Logic*’ by Sundar Sarukkai is a contribution motivated by the history of Indian logic, on the conception of necessity. Logical necessity is presumably absent in Indian logic, where the structure of the logical argument in Indian logic is often given as a reason for this claim. In Indian logic, the analysis of ‘invariable concomitance’ (vyāpti) is of crucial importance and its definitions are very complex. The author argues how vyāpti can be understood in terms of contingent necessity in the Leibnizian sense and also how the complex definitions can be interpreted as an attempt to define contingent necessity in terms of logical necessity.

‘*Fine-grained concurrency with separation logic*’ by Kalpesh Kapoor, Kamal Lodaya and Uday Reddy is a contribution in the area of computer science, on reasoning about concurrent programs. Such reasoning involves ensuring that concurrent processes manipulate disjoint portions of memory but the division of memory between processes is in general not static. The implied ownership of memory cells may be dynamic and shared, allowing concurrent access. Concurrent Separation Logic with Permissions, developed by O’Hearn, Bornat and others (see [6] for various contributions), is able to represent sophisticated transfer of ownership and permissions between processes. The authors demonstrate how these ideas can be used to reason about fine-grained concurrent programs.

‘*Context-sensitivity in Jain Philosophy. A Dialogical Study of Siddharsigani’s Commentary On The Handbook of Logic*’ by Nicolas Clerbout, Marie-Hélène Gorisse, and Shahid Rahman is a contribution on the history of Indian logic. In classical India, Jain philosophers developed a theory of viewpoints (naya-vāda) according to which any statement is always performed within and dependent upon a given epistemic perspective or viewpoint. The Jainas furnished this epistemology with an (epistemic) theory of disputation that takes into account the viewpoint in which the main thesis has been stated. The paper delves into the Jain notion of viewpoint contextualisation and develops a suitable logical system that offers a reconstruction of the Jainas’ epistemic theory of disputation.

‘*A Logic for Multiple-source Approximation Systems with Distributed Knowledge Base*’ by Mohua Banerjee and Aquil Khan is a contribution in the area of mathematics and computer science, focussing on rough sets, which are approximations of sets. The primitive notion is that of an approximation space, which is a pair consisting of a domain of discourse (the knowledge base) and an equivalence relation on that domain (the granularity of information about objects in the domain). The authors focus on the situation where information is obtained from different sources. The notion of approximation space is extended to define a multiple-source approximation system with distributed knowledge base, that can reflect how individual sources perceive

the same domain differently (depending on what information the group / individual source has about the domain). The same concept may then have approximations that differ with individuals or groups.

It is hoped that this issue will generate interest in Logic in India within the wider international community of logicians and philosophers.

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