Summary

Imagine a new type of intelligent computer interface that looks like a conventional notebook but is actually a computer capable of providing information and expertise on a wide range of subjects. The user writes on it like a notebook: outlining thoughts, drawing diagrams or recording data. As you take notes in a class, the Natural Log reads and interprets your writing. It instantly gives you access to related information from a local library or from any part of the world wide web. If you draw a diagram, of perhaps a mechanical device or circuit, the Natural Log can analyze its behavior. A scientist or engineer may wish to manipulate a set of equations or tables of data. The Natural Log will correct algebra, offer simulations of physical or economic systems, and supply statistical analysis. The Natural Log can act as an interactive tutor, giving a student immediate feedback on her work. It can provide relevant sections from a wide range of textbooks or previous problems.

We propose research in four related areas: handwriting recognition, diagram interpretation, information retrieval and reasoning. Much general purpose work has been done in these areas, but we intend to focus our efforts and evaluate our results in one particular area: a flexible pen-based computer interface called the Natural Log. Diagram/figure/equation recognition is a difficult and unsolved problem that lies somewhere between classical handwriting recognition and computer vision. It requires both low level reasoning to analyze ambiguous stroke information, and high-level geometric reasoning to drive the interpretation of a configuration of symbols. Retrieval of information from on-line textbooks and articles will require capabilities that go far beyond that available from keyword retrieval systems like Alta-Vista. The retrieval of natural language documents requires the construction of intermediate representations which are more closely related to document content then a simple list of keywords. We intend to learn these representations directly from large corpora using statistical techniques. Finally the Natural Log will act as an interface to a large collection of computational analysis tools like those available in Matlab, Mathematica, and Spice. In order to provide these tools when appropriate, the Natural Log must represent the semantics of these operations and reason about them.

We believe that by focusing on this one encompassing application several benefits arise. Firstly, meaningful evaluation criteria and stopping points emerge. Stated in full generality any one of the above research areas is a very large and daunting task that has evaded solution for many years. Secondly, we believe that the resulting system will be useful in university level education (and potentially in primary and secondary education). We hope to use the Natural Log as a tutor in MIT undergraduate courses. Thirdly, the breadth of the project allows graduate students with disparate interests to explore, interact and collaborate. For these students the Natural Log will act to reunify the now disparate disciplines of Artificial Intelligences such as vision, reasoning, and natural language. Finally, the notion of the Natural Log has been very motivating for undergraduate students. We have recruited several undergraduate thesis students who are quite excited about the project and each has learned a great deal.