Logic and the set theory

Lecture 1: Introduction

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KAIST, Daejeon, South Korea

Fall semester, 2012

About this course

- I hope that this course to be a practical one where you learn to read and write proofs yourselves. I will not present too much technical materials.
- The lecture pdf will be posted in the following pages 2-3 days before lecture:
- Course homepages: `http://mathsci.kaist.ac.kr/~schoi/logic2011F.html` and the KLMS(moodle) page `http://edu3.kaist.ac.kr` (go to portal, KLMS)
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- Section 1: Logic. The basic purpose is to learn some elementary logic.
  - Arguments
  - Propositional logic
  - Propositional calculus
  - Predicate logic
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- Section 2. How to prove it. We will learn how to prove mathematical statements.
  - Proofs: Proof techniques.
  - Sets, Relations, Functions

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- Section 4: Presentations: Peano axioms and arithmetics, The axiom of choice, Zorn's lemma, Well-ordering, Transfinite recursion Ordinal numbers, cardinal numbers, ordinal cardinal arithmetics.

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Logic

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- Logic concerns how to argue in a “sound manner”.
- Socratic method: This is still the most powerful method of analysing arguments and these are very useful in the field of law. (See http://en.wikipedia.org/wiki/Socratic_method)
- On the other hand, there were Sophists. They believe that truth is not knowable in some extent contrary to Socrates. (http://en.wikipedia.org/wiki/Sophistry)

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Logic

- Basically Socrates, Plato, and his followers believed that by extremely careful analysis and cross-examination can lead to knowledge by building one on top of the already carefully built ideas.
- Aristotelian Syllogism: (http://en.wikipedia.org/wiki/Syllogism) (superceded by Frege and Russell.)
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- There are a lot of controversies here about what constitute truth and sound arguments. These form the main subject of philosophy.
- The main problem here is that to understand anything, we need pure reasoning and much interpretations. How does such happen?
- What we consider as reality is a some rough picture that we inherit from our teachers and other people and social pressure to behave and think in conventional way. This pressure can even come from a very small group in fact.
- Ultimately, I think all science and mathematics belong to humanistic studies and are influenced by humanistic approaches.

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- On the other hand, I am also very concerned about developments such as postmordernism. One should not believe these hazy approach in the humanities too much...
- Postmordernism is quite popular. Postmordernism tries to go beyond.. to haziness?
- In general, asian philosophies such as Confucianism, Taoism, and so on do not study logic or arguments. Neo-confucianism studied some of these questions in 16th century.
- Buddhism has a form of logic. Ancient indians had developed logic.

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Arguments for logical thinking

- What is great about western thinking is that eventhough the world is chaotic and variable, they believe that there are central laws discoverable and understandable by men.
- This is a very good principle that applies today. One should never give up hope in this regard.
- Perhaps, asian culture never tried this because of the religion? Neo-confucian scholars claimed that truth is not understandable by mankind. They tend to make many mysterious statements often ambiguous without knowing much context. Western historians saw the reluctance of the scholars to ask questions about various things that are decided by kings.
- If we believe in mysteries and ambiguities, then where do we end up? The systematic study and axiomatization and reductionism are all important tools to be used throughly before attempting other methods.
- (These methods led us far but many western people are suggesting more holistic view...., i.e., “emergence". How much will it succeed? What is a "right kind" of holism?)

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Arguments against purely logical thinking

- During the development of calculus, there were many controversies. Newton's infinitesimal was considered a nonsense by the philosopher Berkeley.
- Euler wrote many integral and series formulas which would be considered nonsense today.
- Cauchy attacked Euler and started new criteria of convergences.
- The real number system was not defined until Dedekind.
- Riemann started to define surfaces and manifolds. He assumed the existence of some harmonic functions using Dirichlet principle. These were found to be groundless by Weierstrauss.
- Cantor defined ordinals and cardinals...(Hilbert: paradise?)
- To settle these later, mathematicians developed the logical foundation of mathematics.
- A pattern: Mysterious concepts arise. Then we find a new foundation to explain them.
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Mathematics and computer science, science, engineering, so on

- The computer science is most similar to mathematics, more to Intuitive mathematics.... It is unclear whether computer can study all of mathematics... Many mathematician think otherwise.
- Brouwer introduced Intuitive mathematics.
- Today, the set theoretic foundation of Zermelo-Frankel that we use is essentially logic and is endorsed by Gödel.
- Today the alternative to the set theory is the category theory. The category theory assume far less than the set theory. The category theory can also handle intuitive mathematics. But this is much harder to learn for beginning students.
- Note that Category theory made large advances in mathematical fields in the past 20 years.

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A critique of the set theory mathematics

- One obtains answers but the answers are in the set theory.
- The set theory is not the real world...
- So how to interpret the result?
- In general modelling real world mathematically involves a lot of interpretations.... some of which are vague and furthermore, the set theory does not help you here.
- The Peano-Axiom of the set of natural numbers N leads to Gödel's incompleteness. Hence the set theory is insufficient to formalize natural number system $(N, +, \times)$ completely.
- It is well-known that mathematical theories cannot fully justify many accepted results in physics and engineering: Feynman integrals, phase changes, Boltzmann laws, solid state physics,... There are actually too many significant accumulations. (There are some recent progresses here.)
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My thoughts on changing foundation

- It might be a very popular idea. But the main point is that most intuitive type mathematics produce very similar results to current mathematics.
- Even if the foundation changes, most of important part of the mathematical theorems would change little.
- Something close to the set theory and encompassing many ideas of the set theory will replace our current foundation.
- Also, a different foundation is already covered by Category theory and studied.
- However, for applied mathematics, much looser standard can be used very well and soundly.
- In the future, we might have a different foundation which makes the interaction with other field easier.
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- The set theory was introduced by logician to settle many differences of opinions among mathematicians.
- The set theory shows us that there is no self–contradiction to theory once the set theoretical model can be built. However, the set theory cannot show that itself is without self-contradtions.
- This is a very stable system without giving us much troubles.
- With the set theory, mathematics is a very stable field and in principle without much disagreements and general enough to include much of human imagination.
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