1—Initial Ideas on Formal Methods

UIT2206: The Importance of Being Formal

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Structure of the module

- Intro (today)
- Formal reasoning techniques (Weeks 2 to 8)
- Formal methods in other disciplines (Weeks 9 to 12)

Weekly structure

- Lecture: Wednesdays 10–12
- Tutorials: two sessions on Fridays: 8–10 and 10–12 starting next week

Assessment

- Class participation: 10%
- Tutorial participation: 10%
- Assignments: 20%
- Test (Week 9 or 10): 20%
- Presentation (Weeks 10 to 13): 20%
- Essay: 20%

Discreteness

Do atoms exist?

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Brownian motion

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Fundamental fact

Nature is made up of discrete structures

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Central dogma of molecular biology

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DNA makes RNA makes protein

Discreteness in Human Affairs

Language

Natural language is made up of sounds, words, sentences. All of these are discrete structures

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Politics

States, counties, political parties etc are discrete, not continuous phenomena

Naming

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Names are essentially abbreviations for a collection of properties

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A Theory of Naming

Naming is a surprisingly poorly understood concept. 20th century philosophers have made significant progress. Example: Saul Kripke: Naming and Necessity

Abstraction

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Science

Classification of phenomena into discrete categories lies at the heart of many sciences. Example: taxonomy in biology

Reification

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Automated processing

Reification is a prerequisite for automated processing

Self-reference

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Grelling-Nelson paradox

Is “non-self-descriptive” non-self-descriptive or self-descriptive?

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Grelling-Nelson paradox

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Applications

Sometimes, self-reference has surprising results: Gödel’s Theorems, the Halting Problem

Example 1: Books

Problem

How to identify a book uniquely, and world-wide

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Solution

ISBN: 13-digit International Standard Book Number (ISO standard), see example

Example 2: Representing Text

Problem

How to store and transmit text, given that dozens of scripts exists, and hundreds of languages use them.

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Solution

Unicode standardizes more than 109,000 characters, covering 93 scripts, developed by the Unicode Consortium

Example 3: Text Processing

Problem

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Solution: SGML

“SGML was...designed to enable the sharing of machine-readable large-project documents in government, law, and industry. Many such documents must remain readable for several decades—a long time in the information technology field.”

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Solution

HTML, and application of SGML

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... that we are surrounded by formal systems?

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Because they work!

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... that we are surrounded by formal systems?

Because they work!

We do not *need to* know that what underlies complex systems is a formal process. The formal systems allow them to work as expected, always!

The Importance of Being Formal

First Agenda

Find out *in detail* how formal systems work

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Goal

Thorough understanding of formal logic as an example *par excellence* for formal methods

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Approach

Study a series of logics: traditional, propositional, predicate logic

The Importance of Being Formal

Second Agenda

Explore fundamental boundaries of formal reasoning

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Goal

Appreciate Undecidability and Gödel's incompleteness results

The Importance of Being Formal

Second Agenda

Explore fundamental boundaries of formal reasoning

Goal

Appreciate Undecidability and Gödel's incompleteness results

Approach

Study predicate logic deep enough to understand his formal arguments

The Importance of Being Formal

Third Agenda

Explore formal methods across fields

The Importance of Being Formal

Third Agenda

Explore formal methods across fields

Approach

Students write essays and present their findings

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Third Agenda

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Goal

Overview of formal methods and their limitations in our civilization