Questions/Review

- Ex A4
  - Part 1: TM
    - Binary addition
    - Your own
  - Part 2
    - Equivalence with an alternative version
    - Beyond TM

General form of memory? Subroutine?

Unit A5: Overview

- Discuss problems of the day
- Introduce "Computability" properties used to classify problems with respect to TM behavior Intuition first; more precise discussion in Module B
- Discuss the role of proof in this course
- Preview Module A Evaluation Workshop
- Preview Exercise A5 Module A Comprehensive Exercise

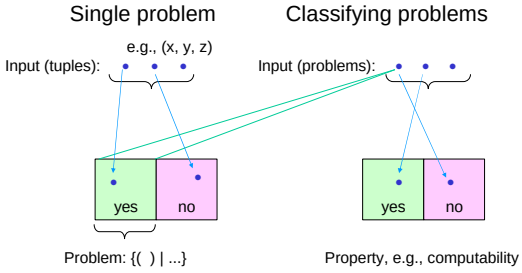
Problems du Jour

- Vending machine
- Compilation
- Termination detection ("halting problem")
- Infinite-loop detection
- Weather forecast
- Jackpot prediction
- Driving

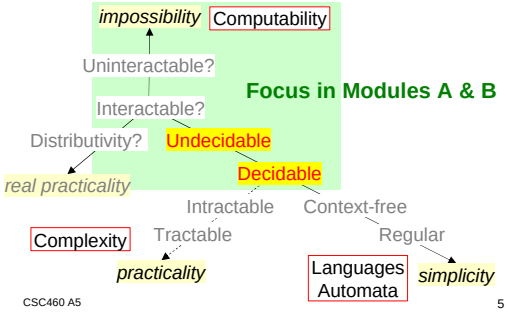
set representations?

Properties
1. Always terminate?
2. Impossible to solve?

Problems and Properties



Overview: Theory of Computation



Decidable Problems

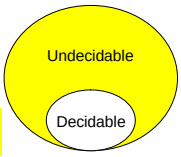
- Property
  - Some TM always terminates and either accepts or dies (rejects).
- Examples
  - Binary number addition
  - Palindrome detection
  - Vending machine
  - Compilation

Decidability Synonyms

- Decidable [of a procedure, problem]
- TM/algorithm exists, i.e., always terminates
- TM-decidable [of a TM]
- Computable [of a procedure/function]
- Solvable [of a problem]
- Recursive [of a set], cf. recursive function

Undecidable Problems

- Property
  - **Not** decidable (*complement* of decidable problems)
  - Equivalently: Not always terminate, or not always end up in either accept state or die
- Examples
  - Halting problem
  - Floor tiling



Members are problems, which are already sets

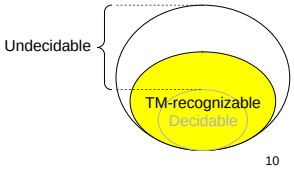
Undecidability Synonyms

- Undecidable
- Unsolvable

- Note: Incorrect definition of "unsolvable" on the earlier version of "Topics" doc. Please fix. I apologize.

TM-Recognizable Problems

- Property
  - Some TM can identify all the acceptable inputs
  - Note: OK if loops on non-acceptable inputs
- Example
  - All of decidable problems
  - Halting problem (undecidable)

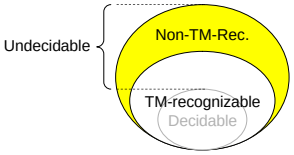


TM-Recognizability Synonyms

- TM-recognizable
- TM exists (but not necessarily always terminates)
- Recursively enumerable (RE) [of a set]

Non-TM-Recognizable Problems

- Property
  - No TM can represent
- Example
  - Infinite loop detection
  - Weather



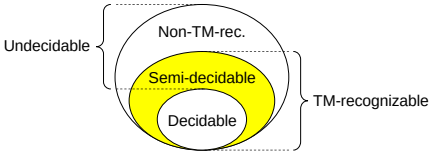
Non-TM-Recognizability Synonym

- Non-TM-Recognizable (non-TM-rec.)
- Non-RE

Semi-decidable Problems

Equivalent terms

- Semi-decidable
- TM-recognizable but not decidable



Property of "Co-"

- co-*X*
  - Consider the complement of a problem
  - If the complement has property *X*, the original problem is called co-*X*.
- Examples
  - Infinite-loop detection is co-TM-recognizable.
    I.e., the complement problem (halting problem) is TM-recognizable.
  - Palindrome detection is co-decidable.

Useful Theorems

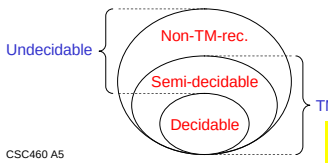
- **Theorem**: Decidable ⇔ TM-recognizable *and* co-TM-recognizable
  - Note: Theorem as a statement in a theory, which needs to be proved
- **Corollary** (a theorem easily derivable from another theorem): The complement of a decidable problem is decidable.

Review: Proofs

- Proof [Text 1.2-1.4]
  - A sequence of justifiable steps of deriving a theorem from axioms and other theorems using rules of inference
- Example proof technique
  - To prove a statement: X ⇔ Y
  - (1) Prove X ⇒ Y, *and* (2) Prove X ⇐ Y

Unit Summary

- With respect to impossibility, problems can be classified into 3 disjoint sets, based on whether a TM exists and/or always gives an answer.



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Your problems?
If not decidable?

Preview

Module A Evaluation Workshop

- Required materials (hardcopy) **print in advance**
  - Module A evaluation form
  - Supporting notes
  - Exercises

Significance of supp. notes?

- Activities
  - Module review exercise
  - Peer discussion
  - Reflection and self-evaluation

Summary Question

- Did you get the big picture of the "computability" part of the Theory of Computation? Explain.
- Questions/Comments/Suggestions

  (make sure to understand the materials and also the evaluation procedure)