CPSC 421/501

Last 2 weeks of class:

Nov 24, 26, Dec 1, 3 (we'll have presentations for CPSC 501 students)

1. Topics suggested on new webpage
   (very short)

2. Presentation: 10-15 minutes, material & questions

3. Topics: Some topics in [Sir] or suggested there.

4. 10-15 very short: You'll probably only have time to:
   1. summarize
   2. present one or two technical
   3. bibliography
   4. ready to answer questions

5. Groups OK up to 4 people

6. Let me know: the topics you want,
   preferences for presentation days 24, 26, 1, 3

7. Many other topics possible — should be related to
   present CPSC 421/501 course, or fundamental
   part of CS theory

8. Email me for topics not on webpage

9. Make sure presentation is understandable to CPSC 421/501


Students: carefully explain any new terminology, new motivation

① Try out your presentation on someone else beforehand, for timing, understandability, and technological problems.

② Send me slides, etc. after the presentation, within 2 days

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Midterm on Nov 5:

① Probably 1-hour exam

② Open book exam

③ Probably we will ask you to leave Zoom cameras on during midterm

④ Cover up to end Chapter 3 (i.e., what we finished 1st part of class on Thursday)

⑤ Midterm start 9:30 am; make sure that your Canvas time zone is set appropriately

⑥ Format: midterm will be usual format! Some T/L, some short answers, some long answers.
You'll have to submit PDF to gradescope.

Cell phone OK to take pic + upload

Ch 3: deciding vs recognizing

language recognized by TM, M, is

\[ \{ w | M(w) = \text{accept} \} = \{ w | M \text{ accepts } w \} \]

This week I'll give a chance to test you uploading system (via gradescope)

Ch 4: Accept \( \text{TM} \) i.e. \( A_{\text{TM}} \) is undecidable

NOT ON EXAM.

Ch 3 includes \( \langle \text{graph} \rangle \), \( \langle \text{T.M} \rangle \), ...

Midterm Nov 3 Nov 5

Tu Th

Spend 40 minutes

Review answers to questions you may have on midterm material
Back to Ch 4!

Last time:

\[ \text{Accept}_{TM} = A_{TM} = \{ \langle M, w \rangle \mid M \text{ accepts } w \} \]

is 1) undecidable \(\leftarrow\) (proof by contradiction,
with negation + "almost self-reference",
\(\text{ closely related to paradoxes.}\))

2) recognizable by

a universal Turing machine \( U \)

[5.1.7]: \( U \), or input \( \langle M, w \rangle \), "simulates" what

\( M \) would do on input \( w \).

give algorithm, can use any finite number of tapes

Now! 1) We'll show that other languages

are undecidable

2) We'll show that some languages are

not recognizable
Idea 2: If \( L \) is undecidable but recognizable, then \( L_{\text{comp}} = \Sigma^* \setminus L \) is unrecognizable.

If so, then \( A_{M} \) is unrecognizable.

If \( L \) is recognizable and \( L_{\text{comp}} \) is recognizable, then \( L \) is decidable.

Recognizable = there is a T.M., \( M \) s.t. \( L = \{ w \mid M \text{ accepts } w \} \)

Decidable = \( \ldots \ldots \) and \( M \) always halts

\( L \) is recognizable by \( M_1 \)

\( L_{\text{comp}} \) is recognizable by \( M_2 \)
If \( w \in L \), run \( M \), on \( w \) eventually reach \( q_{acc} \)

\[ w \in L \implies M \rightarrow^{*} q_{acc} \]

Now run \( M_1 \) and \( M_2 \) simultaneously on input \( w \), then after finite time (\( = \# \) of steps) we halt and know if \( w \in L \) or \( w \notin L \)

If \( M \) is Turing \( M \), \( M(w) = \) run \( M \) on \( w \)

\[ M(w) = \begin{cases} 
  \text{accept} & \text{halt after some finite \# steps} \\
  \text{reject} & \text{doesn't halt}
\end{cases} \]

\( M_1 \) that halts + accepts if \( w \in L \)

\( M_2 \ldots \ldots \) if \( w \notin L \), i.e. \( w \notin L \) \( \implies \) \( w \notin L \) \( \implies \)

\[ \begin{array}{c}
  \text{run one step of } M_2 \\
  \text{run 2nd step of } M_2 \\
  \text{run one step of } M_1 \\
  \text{run 2nd step of } M_1 \\
\end{array} \]

at some finite \# of steps, either \( M_1 \) or \( M_2 \) halt.
Now 5 min break 10:37 → 10:42

Could \((A_{\text{TM}})^{\text{comp}}\) be recognizable?

No, since otherwise

\[
\{ A_{\text{TM}} \text{ is recognizable} \} \rightarrow A_{\text{TM}} \text{ is decidable}
\]

by unversal TM

contradiction

Similarly, \(L\) is recognizable but not decidable

\(\therefore L^{\text{comp}}\) is not recognizable.

Similarly \(\text{HALT}_{\text{TM}}\) is undecidable

\(\therefore\) mimnack the proof that that \(A_{\text{TM}}\) is decidable

\(\therefore\) OR if \(\text{HALT}_{\text{TM}}\) is decidable then \(\text{HALT}_{\text{TM}}\) undecidable
If you could decide $\text{HALT}_{\text{TM}}$ and given $\langle M, w \rangle$ and you want to know if $M(w) = \text{accepts}$, then

\[
M(w) = \begin{cases} 
\text{accepts} & \text{if } M(w) = \text{accepts} \\
\text{rejects} & \text{if } M(w) = \text{rejects} \\
\text{doesn't halt} & \text{if } M(w) \text{ doesn't halt}
\end{cases}
\]

Create $\hat{M}$

\[
\hat{M}(w) = \begin{cases} 
\text{accepts when } M(w) = \text{accepts} & \text{if } M(w) = \text{accepts} \\
\text{doesn't halt } M(w) = \text{rejects} & \text{if } M(w) = \text{rejects} \\
\text{doesn't halt} & \text{if } M(w) \text{ doesn't halt}
\end{cases}
\]

then

\[
M(w) \text{ accepts } \implies \hat{M}(w) \text{ halts}
\]

\[
\text{ doesn't accepts } \implies \hat{M}(w) \text{ doesn't halt}
\]

If $\text{HALT}_{\text{TM}}$ is decidable, run $\text{HALT}_{\text{TM}} \text{ alg}$ on $\langle \hat{M}, w \rangle$. 

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Class steps

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Reely 3.11 (Sip)

Any algorithm that works

convert to a TM algorithm

1-tape, could be 2-tape