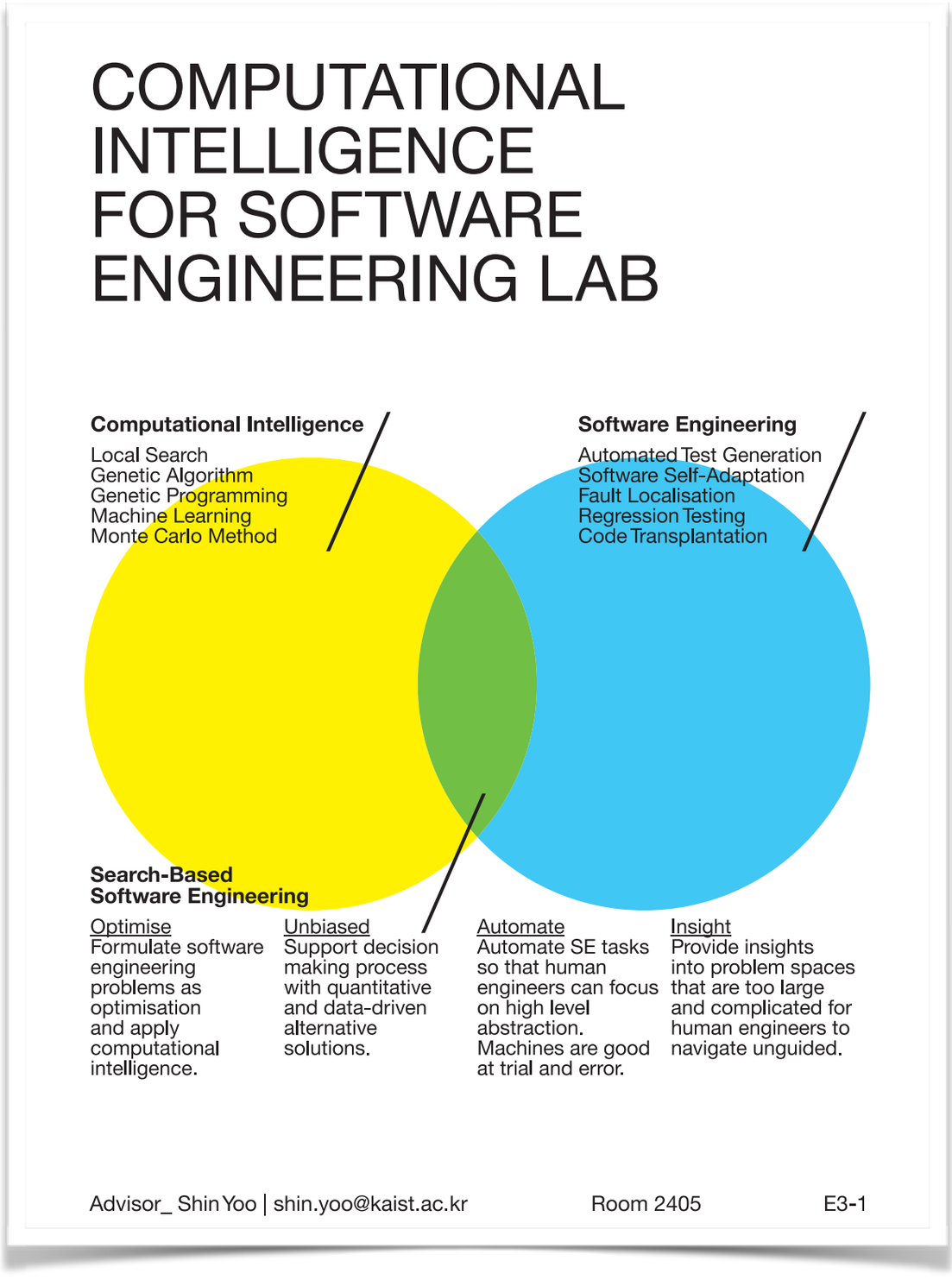
CS402: Introduction to Logic for Computer Science

Shin Yoo

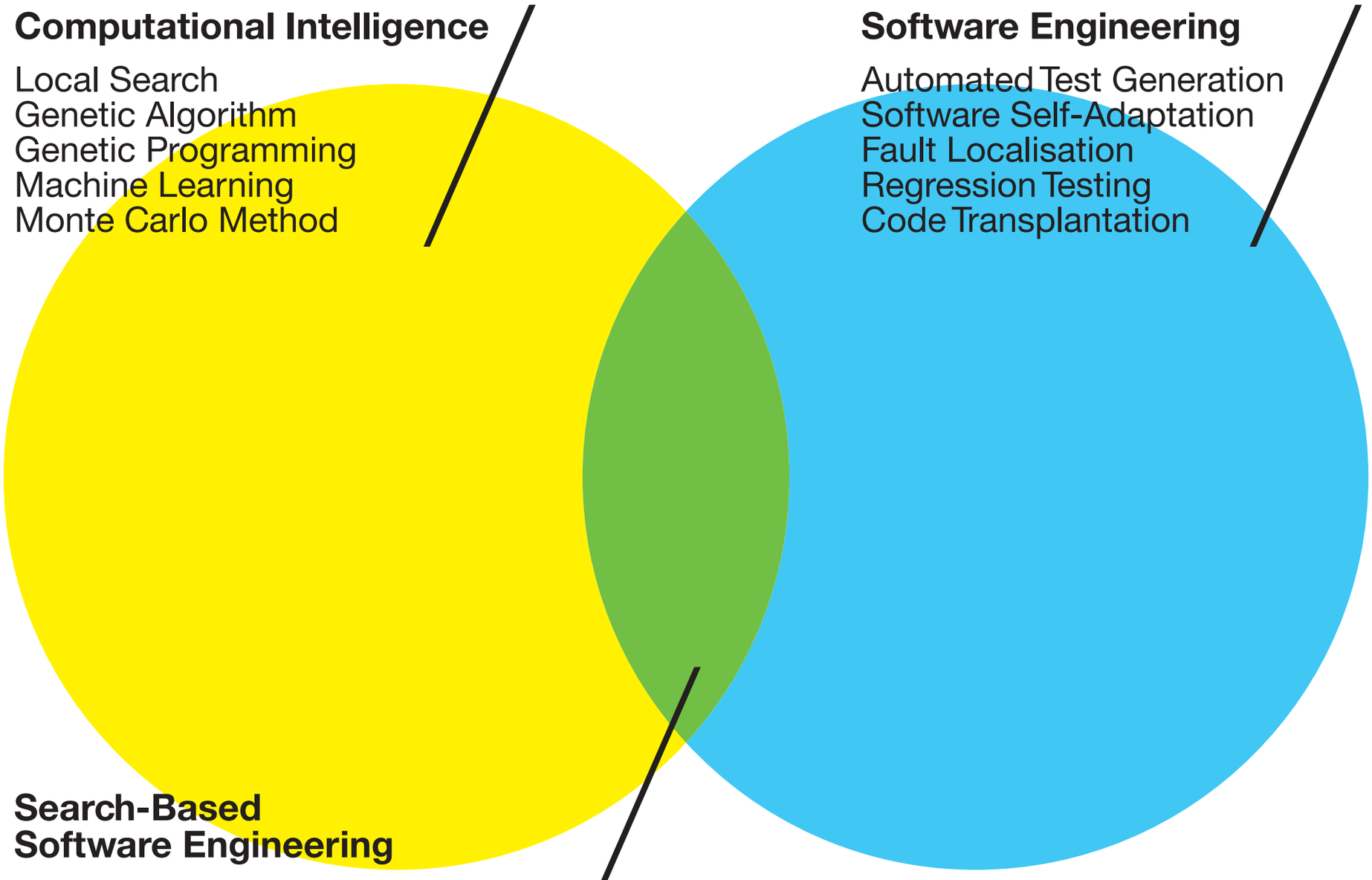
Spring 2017

Me

- Shin Yoo, joined KAIST CS in August 2015
  - PhD at King's College London, UK
  - Assistant Professor at University College London, UK
- COINSE (Computational Intelligence for Software Engineering) Lab
- Research interest: SBSE, regression testing, automated debugging, evolutionary computation, information theory, program analysis…
- shin.yoo@kaist.ac.kr



Disclaimer: this course has (almost) **nothing** to do with COINSE Lab :p



Search-Based Software Engineering

Optimise
Formulate software engineering problems as optimisation and apply computational intelligence.

Unbiased
Support decision making process with quantitative and data-driven alternative solutions.

Automate
Automate SE tasks so that human engineers can focus on high level abstraction. Machines are good at trial and error.

Insight
Provide insights into problem spaces that are too large and complicated for human engineers to navigate unguided.

Introduction to SBSE (1/2)

Shin Yoo
CS492D, Fall 2015, School of Computing, KAIST

There will be a CS454: Artificial Intelligence Based Software Engineering in Autumn 2017.

Syllabus

- This course is about basics of logic used in computer programming. Topics covered in this course include: propositional calculus, predicate calculus, and basic modal logic.

- We will also try to incorporate practical application of logic systems using various tools.

Learning Outcome

- Essentially, we learn
  - Logic systems, different flavours and their differences in expressiveness
  - How to reason formally and algorithmically
- But we also train ourselves to
  - Think and reason formally and symbolically

Course Webpage

- Lecture Materials and Links: http://coinse.kaist.ac.kr/teaching/2017/cs402/

- Coursework Online Submission: KLMS

Pre-requisite

- CS204 Discrete Math
- Ability to build and install *nix software
- ~~Skill to use proper typesetting systems~~
- ~~Knowledge of greek alphabets~~

Because this lies ahead…

Ax. 1. $\{P(\varphi) \wedge \Box\, \forall x[\varphi(x) \rightarrow \psi(x)]\} \rightarrow P(\psi)$
Ax. 2. $P(\neg\varphi) \leftrightarrow \neg P(\varphi)$
Th. 1. $P(\varphi) \rightarrow \Diamond\, \exists x[\varphi(x)]$
Df. 1. $G(x) \iff \forall\varphi[P(\varphi) \rightarrow \varphi(x)]$
Ax. 3. $P(G)$
Th. 2. $\Diamond\, \exists x\, G(x)$
Df. 2. $\varphi \text{ ess } x \iff \varphi(x) \wedge \forall\psi\, \{\psi(x) \rightarrow \Box\, \forall y[\varphi(y) \rightarrow \psi(y)]\}$
Ax. 4. $P(\varphi) \rightarrow \Box\, P(\varphi)$
Th. 3. $G(x) \rightarrow G \text{ ess } x$
Df. 3. $E(x) \iff \forall\varphi[\varphi \text{ ess } x \rightarrow \Box\, \exists y\, \varphi(y)]$
Ax. 5. $P(E)$
Th. 4. $\Box\, \exists x\, G(x)$

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Ax. 4. $P(\varphi) \rightarrow \Box\, P(\varphi)$
Th. 3. $G(x) \rightarrow G \text{ ess } x$
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Ax. 5. $P(E)$
Th. 4. $\Box\, \exists x\, G(x)$

Kurt Gödel's ontological proof
of God's existence.

We will examine this in due course.

But seriously,

- Consider learning how to write in LaTeX: it makes writing logical symbols so much easier.
- Critical skill if you’re going into grad-school ;)
- Think HTML-like mark-up language for typesetting.
- There are online editors such as sharelatex.com

Evaluation

- Mid Term Exam: 30%
- Final Term Exam: 30%
- Various coursework, quiz, etc: 30%
- Class participation: 10%

Questions?

Since we've all done CS204…

First coursework

- Warming-up!
- Due 16:00 2nd March, at the beginning of the lecture.
- Submit hardcopies to the T/A.

CS402
Introduction to Logic in Computer Science

Coursework 1: Warming Up
Due on 16:00, 2 March 2016

1 The Basic

Sherlock Holmes famously stated "Once you eliminate the impossible, whatever remains, no matter how improbable, must be the truth". At the beginning of Spring 2017 term, someone comitted the unthinkable crime of setting a coursework at the very first lecture. Holmes and Watson have four suspects: $\{K(\text{Moonzoo}), R(\text{Sukyoung}), Y(\text{Shin}), Z(\text{Martin})\}$, and evidence eliminated all but Y. Describe the application of the above rule of elimination to this case as best as you can, in the form of formal propositional logic.

2 The Joke

Fill in the blanks in the following joke and explain why.

> Three logicians walked into a bar.
> The bartender asked: 'do you all want beer?'
> The first logician said: 'I don't know.'
> The second logician said: 'I don't know.'
> The third logician said: '_____.'
> The bartender then served _____ pints of beer.

3 The Valid

Represent each of the following in propositional logic, and decide whether it is valid or not.

- "You must be the criminal. I'm sure of this, because you walk with a slight limp. We all know that the criminal walks with a slight limp."
- "We will be able to have class, only if either Shin brought his laptop, or there is a computer in the lecture room. There is no computer in the room. So we will not be able to have class. I say this, of course, because Shin forgot to bring his laptop."

4 The Proof

Prove the following:

- $P \leftrightarrow \neg Q \vdash \neg P \leftrightarrow Q$,
- $R \rightarrow \neg P, Q, Q \rightarrow (P \vee \neg S) \vdash S \rightarrow \neg R$.

Submit a hardcopy at the beginning of lecture at 16:00, 2 March 2016.
Late submissions are not allowed.