Introduction to Logic

IF1221 Computational Logic
Semester II - 2024/2025

Informatics Engineering Study Program
School of Electrical Engineering and Informatics ITB

Lecturers

Lecturers:

- K1:

  Fariska Zakhralativa Ruskanda fariska@informatika.org

  Muhammad Romadhon Al-ghazali algo@staff.stei.itb.ac.id

- K2:

  Dion Tanjung dion.tanjung@staff.stei.itb.ac.id

Vision and Mission STEI ITB

Visi:

Menjadi Institusi pendidikan tinggi, pengembang ilmu pengetahuan Teknik Elektro dan Informatika yang unggul dan terkemuka di Indonesia dan diakui di dunia serta berperan aktif dalam usaha memajukan dan mensejahterakan bangsa.

Misi:

1. Menyelenggarakan pendidikan tinggi dan pendidikan berkelanjutan di bidang teknik Elektro dan Informatika dengan memanfaatkan teknologi komunikasi dan informasi
2. Mengikuti (memelihara) keterkinian (state of the art) serta mengembangkan ilmu pengetahuan Teknik Elektro dan Informatika melalui kegiatan penelitian yang inovatif.
3. Mendiseminasikan ilmu pengetahuan, teknologi dan pandangan/wawasan Teknik Elektro dan Informatika yang dimiliki kepada masyarakat baik melalui lulusannya, kemitraan dengan industri atau lembaga lainnya maupun melalui kegiatan pengabdian pada masyarakat dalam rangka membentuk masyarakat berkearifan teknologi.

Program Educational Objective

Setiap lulusan IF ITB diharapkan (dalam 3-5 tahun setelah lulus):

a. Lulusan akan memiliki karir yang sukses dan menjadi seorang professional yang produktif di bidangnya
b. Lulusan dapat melanjutkan dan menyelesaikan pendidikan lanjutannya
c. Lulusan dapat berkembang secara professional melalui pembelajaran mandiri dan memiliki peran aktif dan **kepemimpinan** dalam pengembangan alat, teknologi dan metodologi baru.

Student Outcome

Graduates of the program will have an ability to:

1. Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.
2. Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
3. Communicate effectively in a variety of professional contexts.
4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
5. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.
6. Apply computer science theory and software development fundamentals to produce computing-based solutions.

Learning Outcomes for IF1221

1. Menjelaskan persoalan dalam bahasa alami ke dalam representasi logika proposisional
2. Menjelaskan persoalan dalam bahasa alami ke dalam representasi logika relasional
3. Menunjukkan bukti atau membuat kesimpulan dari fakta/premis yang ada/diberikan menggunakan bukti proposisional/relasional
4. Menunjukkan bukti atau membuat kesimpulan dari fakta/premis yang ada/diberikan menggunakan resolusi proposisional/relasional
5. Menyusun rancangan dan mengimplementasikan sebuah program sederhana dalam bahasa Prolog untuk menyelesaikan persoalan sederhana, berdasarkan pada pembuktian teorema otomatis
6. Melakukan evaluasi sebuah program Prolog yang diberikan, berdasarkan pada persoalan yang diselesaikan

Courses

- Credits: 2 credit points
- Courses:
  - Attending classes 1 hour 40 minutes/week (14 weeks):
    - Tuesday (10.00 – 11.40)
    - attendance is obligatory.
  - Assignments
  - Homework and quiz (individually)
  - Midterm Exam (week 8); Final Exam (week 16)
- No additional exam/ quiz

Course Media

- Course materials and assignments:

   Edunex

  IF1221 Computational Logic [Parent Class]

  https://edunex.itb.ac.id/courses/73108/preview

  course token: W1J FDY

- Communication:

   Ms-Teams

  IF1221 Logika Komputasional (2024-2)

  team code: ddrlurr

Courses contents

1. Introduction
2. Concept of logics
3. Propositional Logics (syntax, semantic, proofing)
4. First Order Predicate Logics (syntax, semantic, proofing)
5. Introduction to Proofing Theory
6. Declarative Programming Prolog
7. Simple Application using Prolog
8. Lab Works

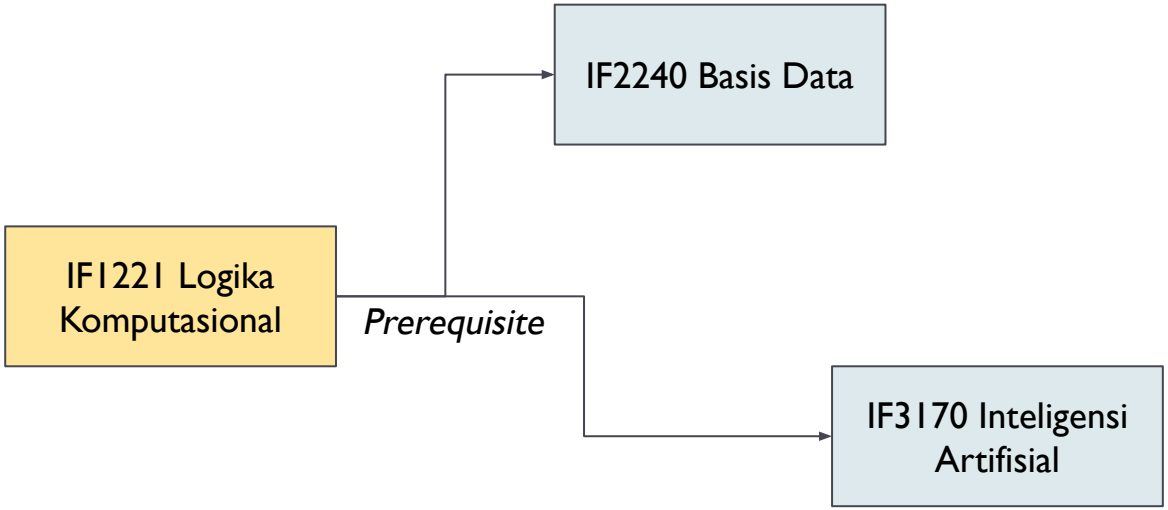
Grading

- Homework : 2,5%
- Assignments and Lab Works : 25%
- Quiz : 17,5%
- Midterm Exam : 27,5%
- Final Exam : 27,5%
- Dishonesty E

References

- Lecture Notes in Stanford University: Introduction to Logic, can be accessed at http://intrologic.stanford.edu/homepage/materials.html (Pustaka utama)
- Mathias Schilling, Introduction to Logic Programming with Prolog, 2017, can be accessed at https://www.matchilling.com/introduction-to-logic-programming-with-prolog/
- Stuart J Russell & Peter Norvig, Resources of topics in Artificial Intelligence: A Modern Approach, 4th Edition, Global Edition Paperback, Pearson, 2021, http://aima.cs.berkeley.edu/
- Aaron Krauss, Declarative Programming with Prolog, 2018, can be accessed at https://thecodeboss.dev/2018/06/declarative-programming-with-prolog-part-1-getting-started/
- Patrick Blackburn, Johan Bos, and Kristina Striegnitz, Learn Prolog Now!, last accessed November 2019, can be accessed at http://www.learnprolognow.org/lpnpage.php?pageid=online

Hubungan IF1221 dengan MK IF Lain



Introduction to Logic

Logical Sentence and Proof

- Logical Sentences:
  The red block is on the green block.
  The yellow block is on the green or the blue block.
- Conclusion from all possible sets is impractical
- Use **Logical Reasoning:** the application of reasoning rules to derive logical conclusions and produce a *logical proofs*
- ***Logical Proofs*** sequences of reasoning steps that leads from premises to conclusions
- Example:

  - **The red block is on the green block.**
  - The yellow block is on the green block **or** the blue block.

  - **The yellow block is on the blue block.**

Introduction

- Natural Language works well
- But sentences in natural language can be:
  - complex
  - ambiguous
  - failing to understand the meaning → reasoning errors
- Example

The cherry blossoms in the Spring.

The cherry blossoms in the Spring sank.

There's a girl in the room with a telescope

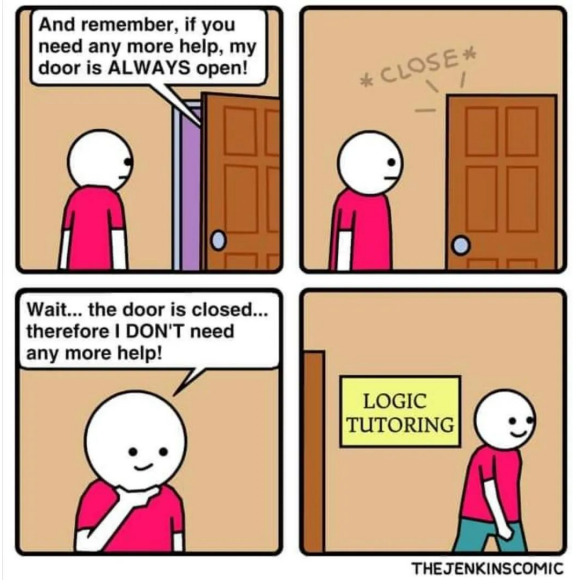
Reasoning in Natural Language

- Good ('correct') reasoning

  Water is better than tea.

  Tea is better than soda.

  Therefore, water is better than soda.



- How about this?

  Bad grade is better than nothing.

  Nothing is better than good grade.

  Therefore, bad grade is better than good grade.

→ We need Logic

What is Formal Logic

- A formal language
  - Syntax: what expressions are legal
  - Semantics: what legal expressions mean
  - Proof system: a way of manipulating syntactic expressions to get other syntactic expressions (which will tell us something new)

Formalization

- *Simple sentences*

  Mary loves Pat. p

  Mary loves Quincy. q

  It is Monday. m

  It is raining r

- *Premises*

  $p \rightarrow q$

  $m \wedge r \rightarrow p \vee q$

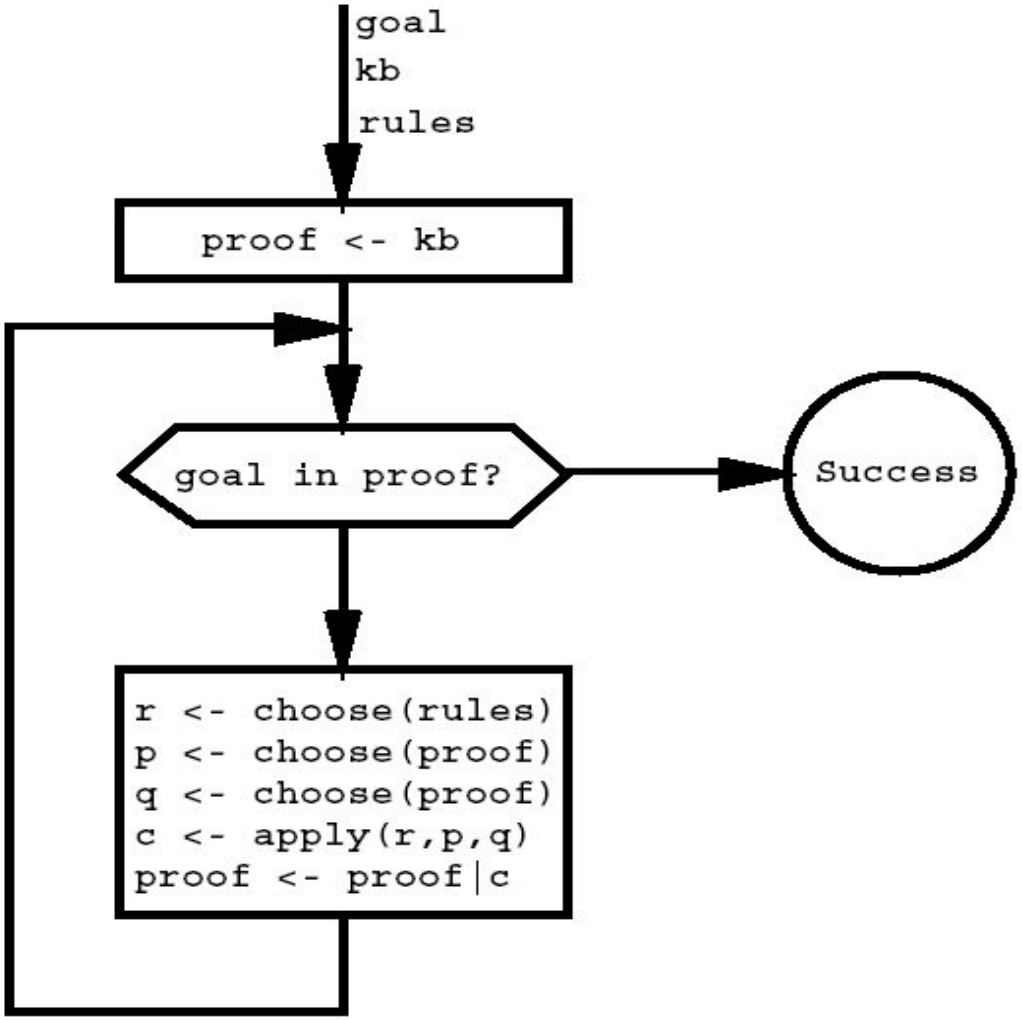
- *Question:*
  - *does Mary love Pat?*
  - *does Mary love Quincy?*

Rule of Inference

- Propositional Resolution
  - If *pi* on the left hand side of one sentence is the same as *qj* in the right hand side of the other sentence, it is okay to drop the two symbols, with the proviso that *only one* such pair may be dropped.
  - If a constant is repeated on the same side of a single sentence, all but one of the occurrences can be deleted.
- Example

$$\frac{p \Rightarrow q \qquad q \Rightarrow p}{p \Rightarrow p} \qquad \frac{p \Rightarrow q \qquad q \Rightarrow}{p \Rightarrow} \qquad \frac{p \Rightarrow q \qquad q \Rightarrow r}{p \Rightarrow r}$$

Automated Reasoning



Formal Logic vs Computational Logic

- Formal Logic
  - Syntax, semantics, correctness and completeness
  - Emphasis on minimal sets of rules to simplify analysis
  - These rules are not always easy to implement or efficient
- Computational Logic
  - Syntax, semantics, correctness, completeness
  - Also concerned with efficiency
  - Emphasis of different languages and different sets of rules
  - Attention to those that better suited to automation

Application of Automated Reasoning: AI

- Mathematics

  Group Axioms

  $(x \times y) \times z = x \times (y \times z)$

  $x \times e = x$

  $e \times x = x$

  $x \times x^{-1} = e$

  Theorem

  $x^{-1} \times x = e$

  Tasks:

  Proof Checking

  Proof Generation

Application of Automated Reasoning: Database

- Deductive Database Systems

parent

art	*bob*
art	*bea*
bea	*coe*

$parent(art,bob)$

$parent(art,bea)$

$parent(bob,coe)$

Queries

```
query(X,Z) :- parent(X,Y) & parent(Y,Z)
```

Constraints

```
illegal :- parent(X,X)
illegal :- parent(X,Y) & parent(Y,X)
```

Review

- Reasoning: information → conclusion
  - Deduction, Induction, Abduction, Analogy
  - Which one is truth preserving?
- Formal Logic
  - Formal language → syntax, semantics, proof systems
  - Encode information, legal transformation
- Computational Logic → Automated Reasoning
  - Formal language → syntax, semantics, proof systems
  - Encode information, legal transformation, efficiency
  - Propositional logic: proposition, interrelationship*
  - Relational logic: object, interrelationship*

*: in the following courses