Prolog

“**Pro**gramming using **log**ic”

Nik Sultana

With thanks to Andy Rice and Alastair Beresford

Aims

- **Learn Prolog**
- **Reflect about deep questions**
    - What's a declarative language?
    - How does Prolog compare/relate to other languages I know?
    - What kind of problems would I use this language for?
- As a side-effect: learn how to **model problems using logic** (a.k.a write programs in Prolog).

Why?

- **Technical depth**, and exposure to different ideas.
- Prolog **brings theory to life**: discrete maths, database theory, program semantics, logic and proof.
- Prolog-based languages are **useful**.
  (Next slide)

Prolog is a living language

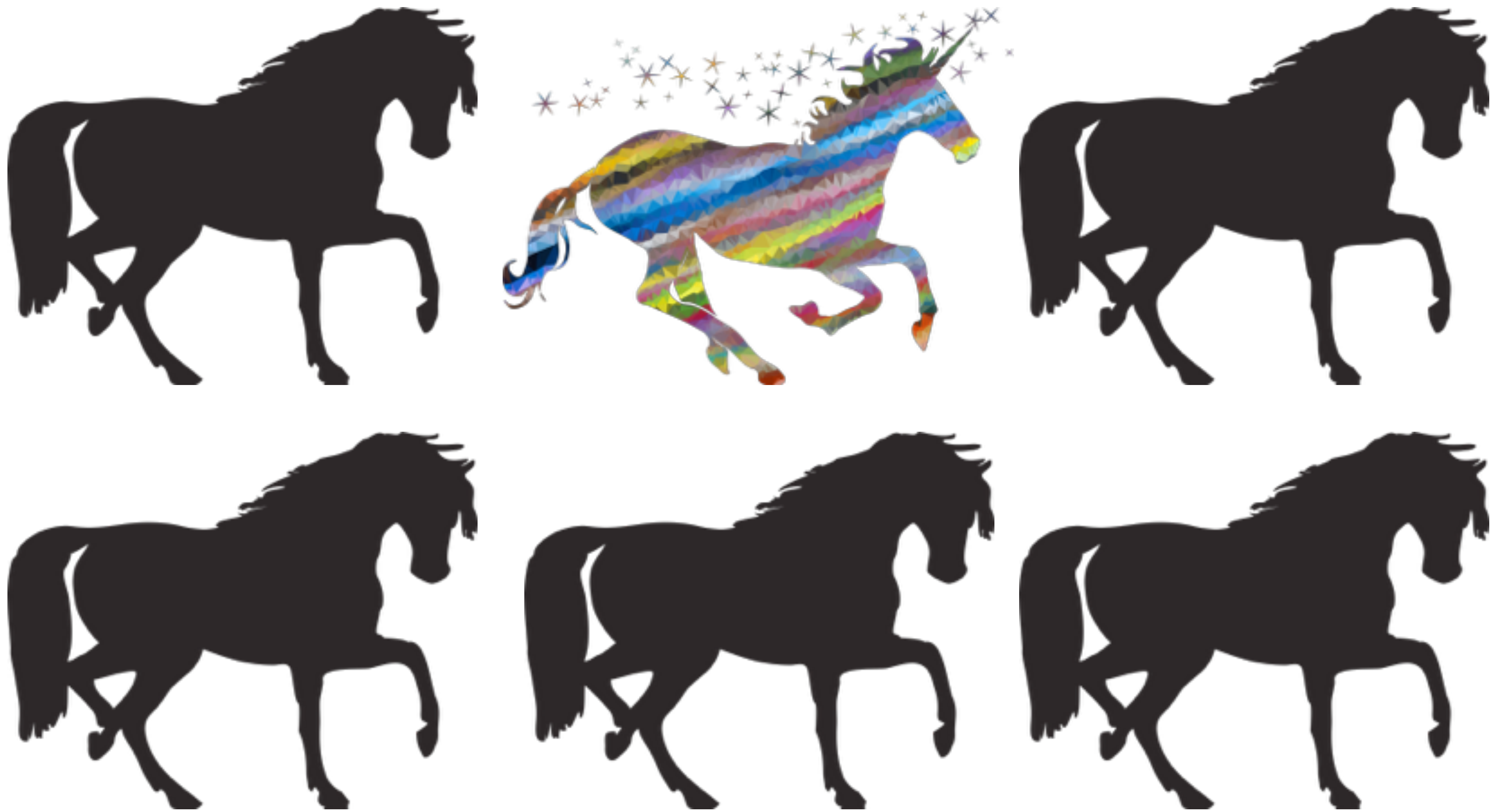
Prolog and its derivatives are used in Software-defined networking, various products (Datomic, LogicBlox, SEMMLE), resource planning, automated trading, law enforcement, …

You don’t have to be a logician to use Prolog.
(You don’t have to be French to speak French…)

How did we get here?

- Prolog emerged from research on **logic**, **programming** and **linguistics**.
- **Many years** of research by **many people** in **different disciplines**.
- For more background see:
  - “The early years of logic programming” by Kowalski
  - “The birth of Prolog” by Colmerauer

This course is taught differently to all the others



https://openclipart.org/

Course content will be through **videos** rather than lectures

- Videos of all the content are **available online**.
- You can watch them whenever you want.
  - Useful for revision.

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"I can watch them naked at 4am while eating cereal. Also, I can re-watch the parts that I haven't understood ... I can pause the lecture and google something ... or even write some relevant code while the lecture is ongoing, all without missing anything!"

Student pre-course survey

We are collecting statistics about how you use the site

- Your supervisor can see how you are progressing.
- We will anonymise the data once the course is over.
- The data will not be used to assess you.


Prolog Home > (ns441@cam.ac.uk)

Programming in Prolog

Welcome to the Prolog course! We hope you enjoy the material. Please get in contact with us via email if you experience any technical issues using this site. Additional course material:

- All exercises in a single PDF
- All slides in a single PDF
- Source code for anagram.pl for video 7
- Course errata, check here for errors in slides or videos

Alastair Beresford and Andrew Rice.
October 2014

Session 1: Thursday 8th October

- Prolog basics 14m46s (exercises)

Session 2: Tuesday 13th October

- Solving a logic puzzle 13m57s (exercises)
- Prolog rules 6m39s (exercises)
- Lists 11m02s (exercises)

Session 3: Thursday 15th October

- Arithmetic 19m32s (exercises)
- Backtracking 29m06s (exercises)

Session 4: Tuesday 20th October

- Generate and test 14m07s (exercises)
- Symbolic 17m34s (exercises)

Session 5: Thursday 22nd October

- Cut 17m36s (exercises)
- Negation 10m52s (exercises)
- Databases 5m59s (exercises)

Session 6: Tuesday 27th October

Why?

- **Technical depth**, and exposure to different ideas.
- Prolog **brings theory to life**: discrete maths, database theory, program semantics, logic and proof.
- Prolog-based languages are **useful**.
  e.g., Software-defined networking, NLP, recent products (Datomic, LogicBlox, SEMMLE), resource planning, automated trading, law enforcement

(Recall slide. **Let's explore the bigger Why next.)**

Programming is about
processing information

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based on some
model of the problem

Programming is about
processing information
based on some
model of the problem,
and involves
changing the world
to achieve a result.

Programming **languages** support us in lifting this **cognitive** load.

Computers then carry out automated processing.

- Programming ultimately results in **changing the world** (side-effects are necessary)…
- …if only by **redistributing voltages** on tiny scraps of silicon!
- But we don't **think** at that low-level scale!
  "We don't design bridges by using quantum physics".
- We need **abstractions** — programming languages provide us with these.
- **Prolog's abstractions**: terms (including variables, which have a special role) and clauses.
  Simple but powerful.


MAKE
PROGRAMMING
GREAT AGAIN

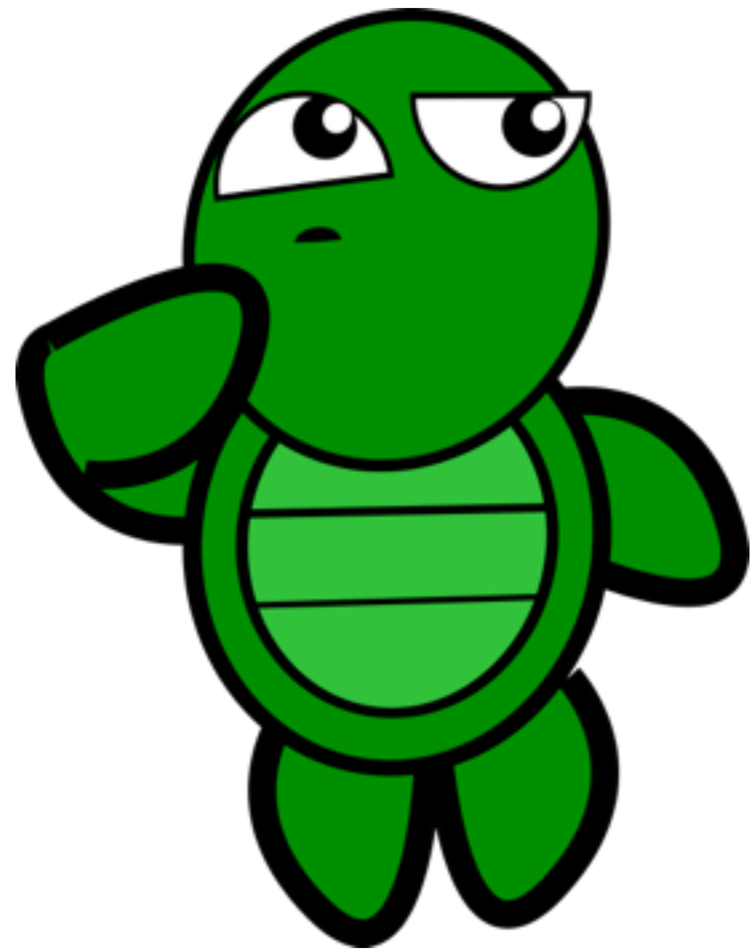
Beware oversimplification

e.g., “Best language ever”

Now with more lambdas!

https://i.imgur.com/Sex1E8m.jpg

Cultivate judgement.



i.e., The best language for **the task at hand, given its expressiveness, compiler targets, toolchain support, abundance of trained programmers, who else uses it, …, budget and deadlines.**

Spoiler:
3 things about Prolog

- Program with **relations, not functions**.
  We need to think slightly differently from "calling a function" or "passing parameters".

- Giving a **procedural interpretation to logic**. As a result, lose some properties (e.g., commutativity) but gain others (better control over search space).

- **Computation by deduction**.
  Compute with knowledge, as formalised in FOL.
  In Prolog, truth = provability, falsehood = unprovability, both in a "small world".

Example

List membership.

Relation vs Function

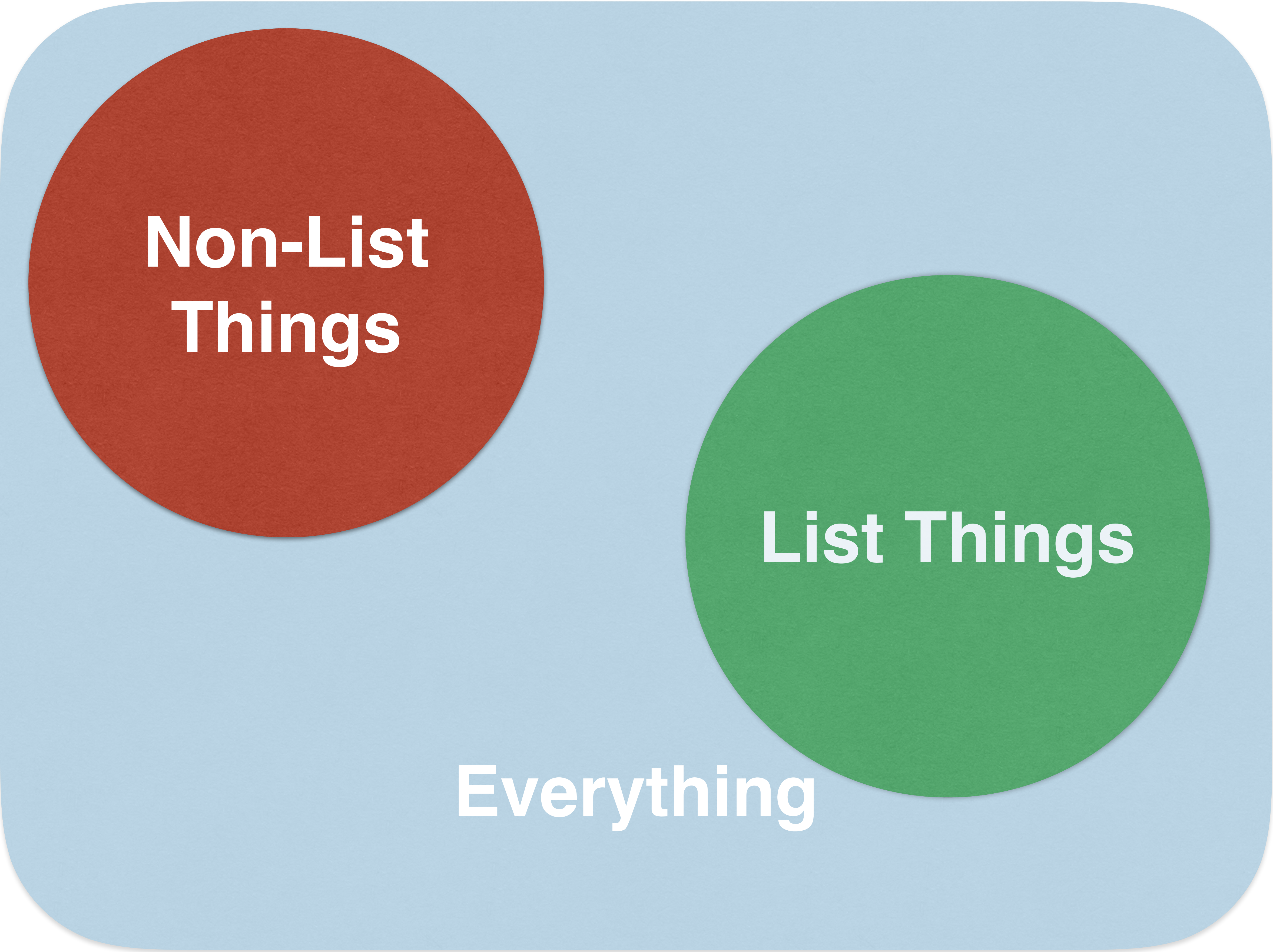
$$\text{member}_R \subseteq (\text{Thing} * \text{ListThing})$$

$$\text{member}_f \in (\text{Thing} * \text{ListThing} \Rightarrow \text{bool})$$

(Excepting side-conditions, since they'd apply similarly to functions and relations)

- With **functions**, you have **inputs and outputs**.
- With **relations**, any of the **parameters** could be the inputs or outputs.

Everything


Non-List
Things
List Things
Everything

Everything (a.k.a. Herbrand Universe)

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Non-List Things	Lists Things
1	[1]
2	[1,1]
3	…
…	[1,2,3]
	[1,2,3,1]
	…
	[[1],[2,3],1]
	…

Every possible assertion (a.k.a. Herbrand Base)

Every possible assertion (a.k.a. Herbrand Base)

member(1,[1])
member(1,[1,1])
member(1,[1,2,3])
member(1,[1,2,3,1])
member(1,[[1],[2,3],1])
…
member(2,[1])
member(2,[1,1])
member(2,[1,2,3])
member(2,[1,2,3,1])
member(2,[[1],[2,3],1])
…

But what makes some assertions true but others false?

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member(1,[1])

member(1,[1,1])

member(1,[1,2,3])

member(1,[1,2,3,1])

member(1,[[1],[2,3],1])

…

~~member(2,[1])~~

~~member(2,[1,1])~~

member(2,[1,2,3])

member(2,[1,2,3,1])

~~member(2,[[1],[2,3],1])~~

…

Which is the ‘membership’ relation I seek?

Relations between
Things and Lists

R1(Thing,List)

R2(Thing,List)

R3(Thing,List)

…

Which is the 'membership' relation I seek?

Relations between Things and Lists

R1(Thing,List)

R2(Thing,List)

R3(Thing,List)

…

Example behaviours

- Empty relation
- Thing is an element of List
- Thing is NOT an element of List
- Thing is the GREATEST element of List
- Thing is the 1st element of List
- Thing is the 2nd element of List

…

Which is the ‘membership’ relation I seek?

Answer: this is what your Prolog implementation specifies.

Demo

All other “lectures” will take place in Intel Lab

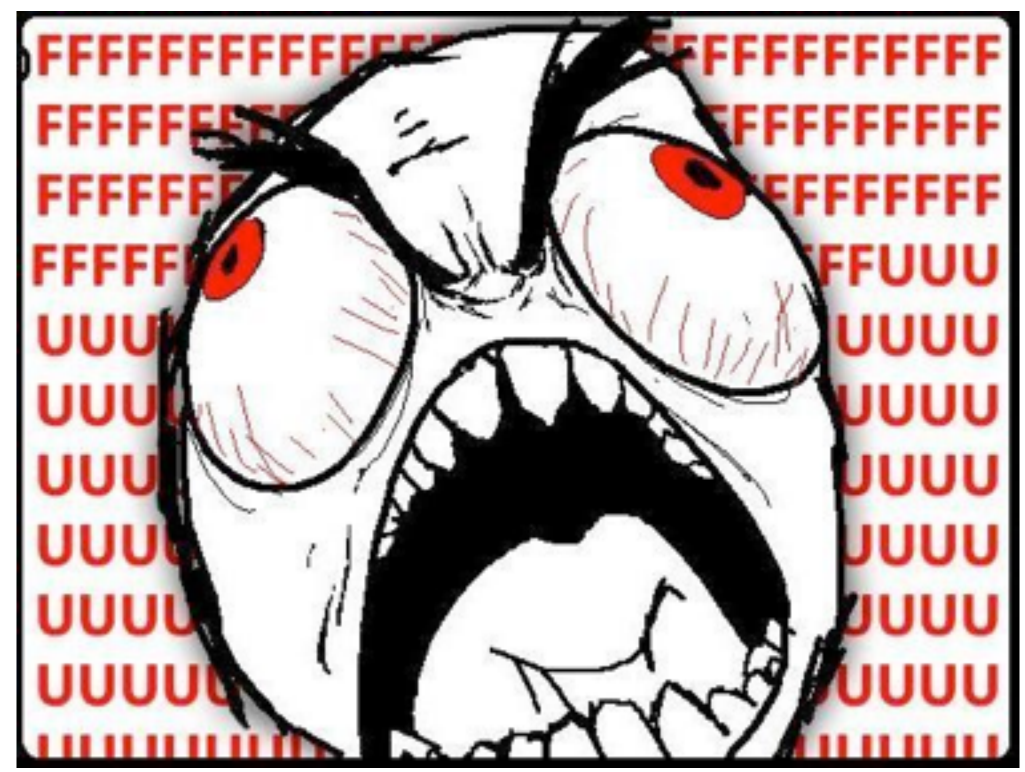
- Bring your own **laptop+headphones**.
- We'll be there to answer your questions and talk to you about the course.
- You are free to work through the course in your own time if you prefer.

Question book

- **Help you review** the course material.
- Questions **categorised** {Bookwork, Shallow, Deep, Open}.
- Can be used for supervisions, self-study, and revision.

Feedback and problems

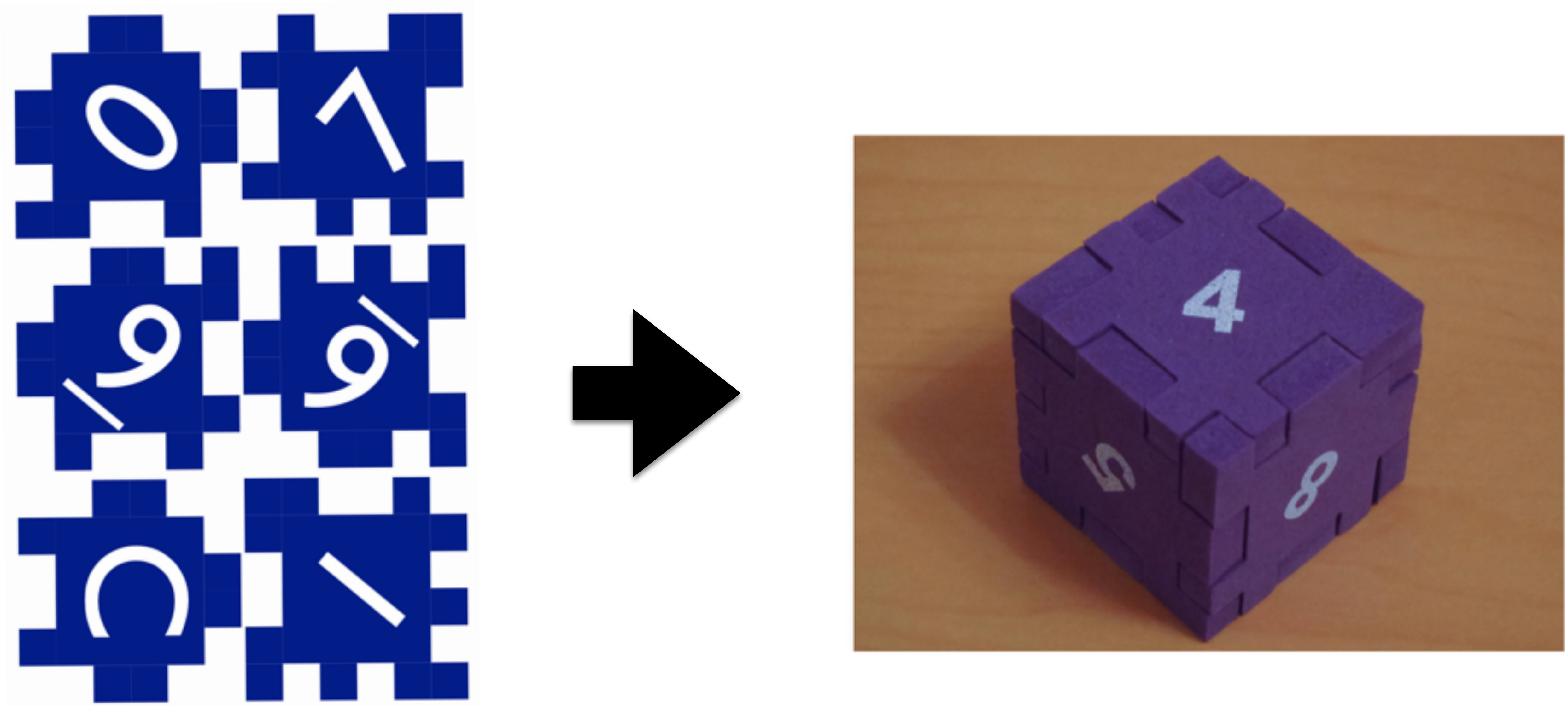
- If you are **stuck**:
  - come to a lab session (Intel Lab)
  - talk to your peers
  - talk to your supervisor
- If the software isn't working then email me.



(Not actual student experiencing Prolog)

Assessment is through practical **exercise** (Tick) and an **exam** question

- Tick’s due date announced shortly by email. Exercise details on the course website.
- You need to complete either the Prolog or the C/C++ exercise.
- There is one Prolog question in the exam.



In Tick we'll also look for good programming style.

- **Simple is often best.** "Clever" often leads to overengineering, technical debt, ….
- **Readability is essential.**
  - Reason: it makes it easier to evaluate correctness, and maintain the program.
    cf. "Obfuscated C contest"
  - For coding style advice, see "Coding Guidelines for Prolog" by Covington et al.
    - Or "The Elements of Programming Style"
      https://en.wikipedia.org/wiki/The_Elements_of_Programming_Style
  - Practice empathy, think of the reader (of your code).

Send me your videos

- Explain something in the course.
  - Worked solution to supervision question or a tripos question
- If they are clear and correct I'll include them in the course and credit you as a contributor at the top of the course webpages. (CV points!)
- Avoid filming naked at 4am..
- **(Explaining something is a good way to learn it)**

Wrap-up: Objectives

- be able to write programs in Prolog using techniques such as **accumulators** and **difference structures**;

- know how to model the **backtracking** behaviour of program execution;

- appreciate the **unique perspective** Prolog gives to problem solving and algorithm design;

- understand how **larger programs** can be created using the basic programming techniques used in this course.