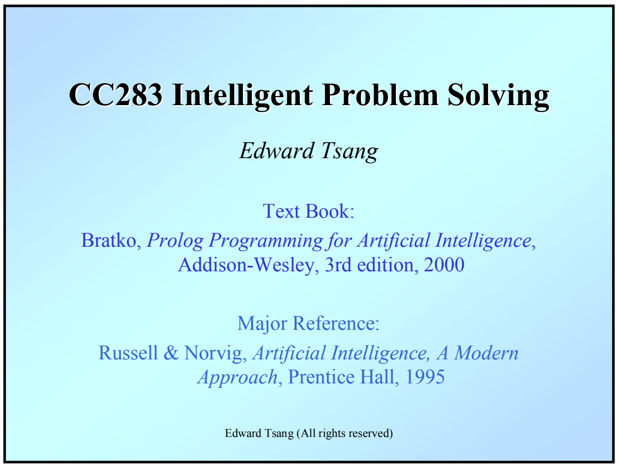
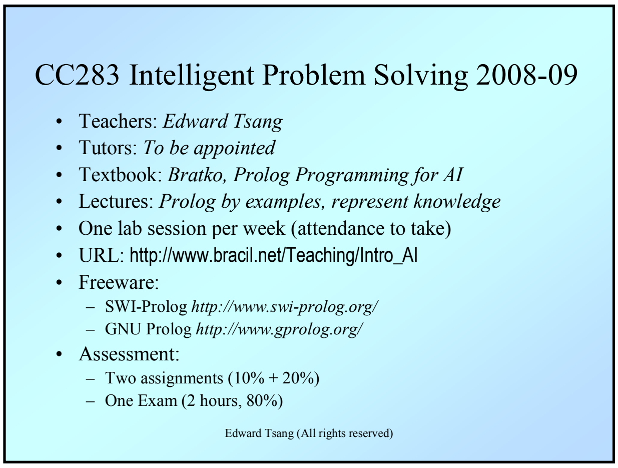


CC283 Intelligent Problem Solving

Edward Tsang

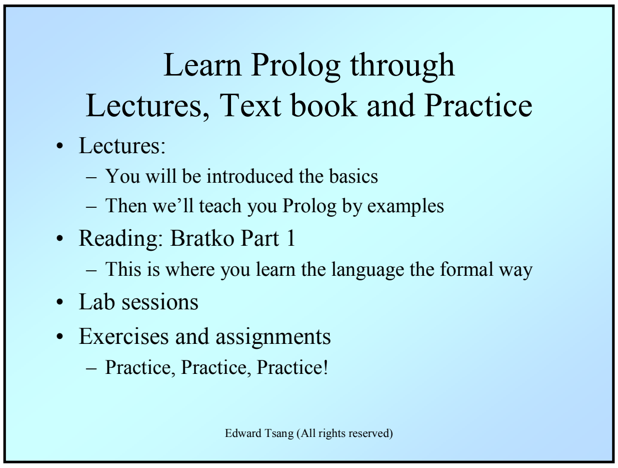
Text Book:
Bratko, *Prolog Programming for Artificial Intelligence*,
Addison-Wesley, 3rd edition, 2000

Major Reference:
Russell & Norvig, *Artificial Intelligence, A Modern Approach*, Prentice Hall, 1995



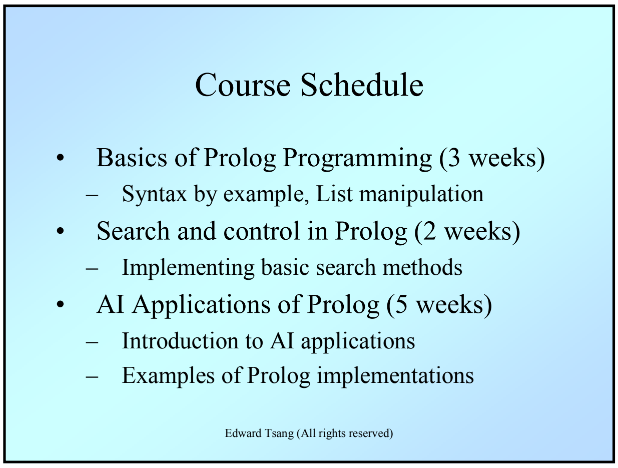
CC283 Intelligent Problem Solving 2008-09

- Teachers: *Edward Tsang*
- Tutors: *To be appointed*
- Textbook: *Bratko, Prolog Programming for AI*
- Lectures: *Prolog by examples, represent knowledge*
- One lab session per week (attendance to take)
- URL: http://www.bracil.net/Teaching/Intro_AI
- Freeware:
  - SWI-Prolog *http://www.swi-prolog.org/*
  - GNU Prolog *http://www.gprolog.org/*
- Assessment:
  - Two assignments (10% + 20%)
  - One Exam (2 hours, 80%)



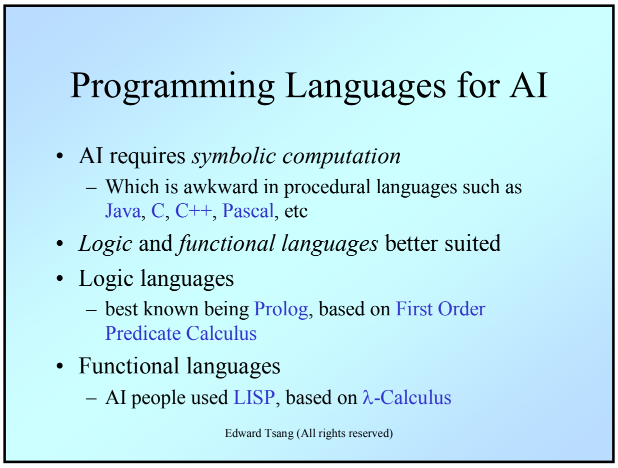
Learn Prolog through Lectures, Text book and Practice

- Lectures:
  - You will be introduced the basics
  - Then we'll teach you Prolog by examples
- Reading: Bratko Part 1
  - This is where you learn the language the formal way
- Lab sessions
- Exercises and assignments
  - Practice, Practice, Practice!



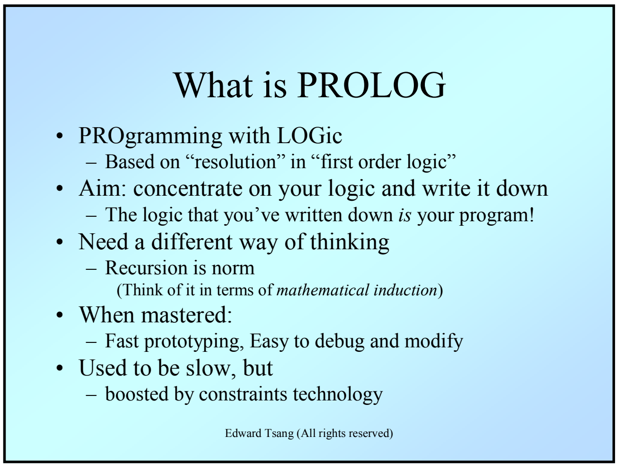
Course Schedule

- Basics of Prolog Programming (3 weeks)
  - Syntax by example, List manipulation
- Search and control in Prolog (2 weeks)
  - Implementing basic search methods
- AI Applications of Prolog (5 weeks)
  - Introduction to AI applications
  - Examples of Prolog implementations



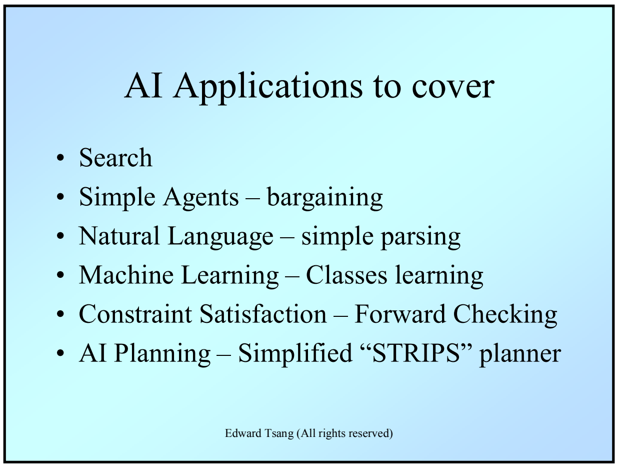
Programming Languages for AI

- AI requires *symbolic computation*
  - Which is awkward in procedural languages such as Java, C, C++, Pascal, etc
- *Logic* and *functional languages* better suited
- Logic languages
  - best known being Prolog, based on First Order Predicate Calculus
- Functional languages
  - AI people used LISP, based on λ-Calculus



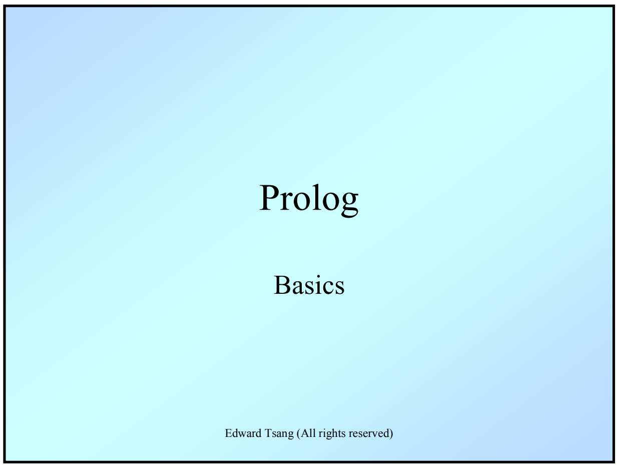
What is PROLOG

- PROgramming with LOGic
  - Based on "resolution" in "first order logic"
- Aim: concentrate on your logic and write it down
  - The logic that you've written down *is* your program!
- Need a different way of thinking
  - Recursion is norm
    (Think of it in terms of *mathematical induction*)
- When mastered:
  - Fast prototyping, Easy to debug and modify
- Used to be slow, but
  - boosted by constraints technology



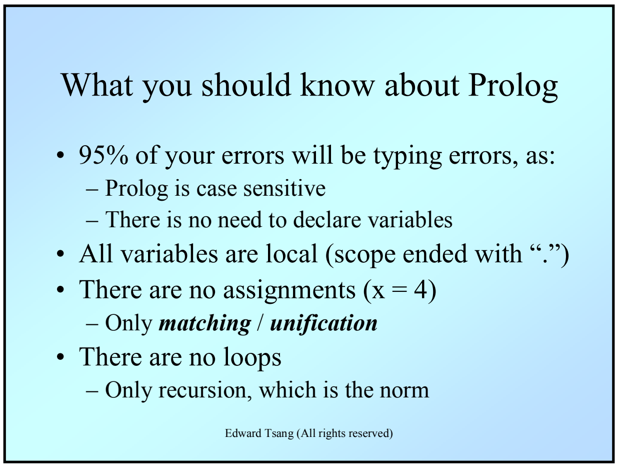
AI Applications to cover

- Search
- Simple Agents – bargaining
- Natural Language – simple parsing
- Machine Learning – Classes learning
- Constraint Satisfaction – Forward Checking
- AI Planning – Simplified "STRIPS" planner



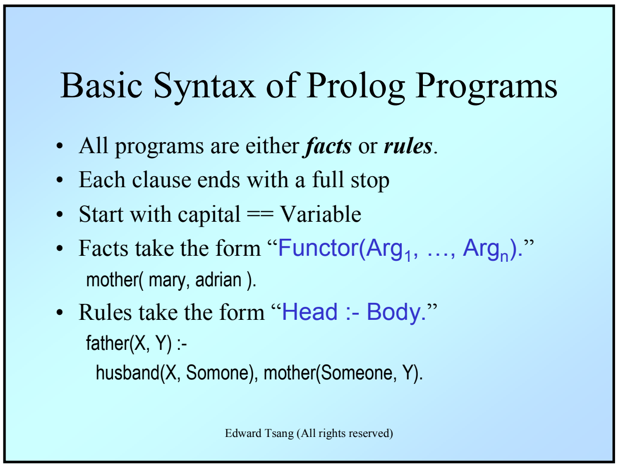
Prolog

Basics



What you should know about Prolog

- 95% of your errors will be typing errors, as:
  - Prolog is case sensitive
  - There is no need to declare variables
- All variables are local (scope ended with ".")
- There are no assignments (x = 4)
  - Only ***matching*** / ***unification***
- There are no loops
  - Only recursion, which is the norm



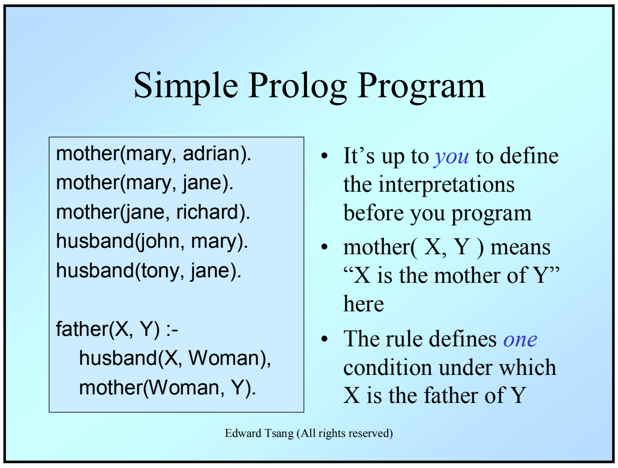
Basic Syntax of Prolog Programs

- All programs are either ***facts*** or ***rules***.
- Each clause ends with a full stop
- Start with capital == Variable
- Facts take the form "Functor(Arg$_1$, …, Arg$_n$)."

```
mother( mary, adrian ).
```

- Rules take the form "Head :- Body."

```
father(X, Y) :-
  husband(X, Somone), mother(Someone, Y).
```

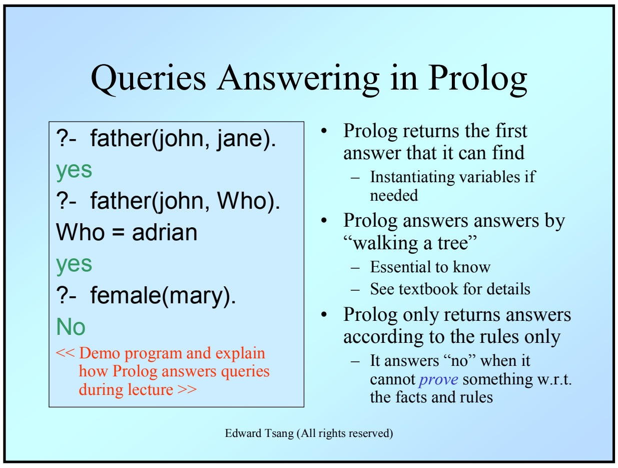


Simple Prolog Program

```
mother(mary, adrian).
mother(mary, jane).
mother(jane, richard).
husband(john, mary).
husband(tony, jane).

father(X, Y) :-
    husband(X, Woman),
    mother(Woman, Y).
```

- It's up to *you* to define the interpretations before you program
- mother(X, Y) means "X is the mother of Y" here
- The rule defines *one* condition under which X is the father of Y

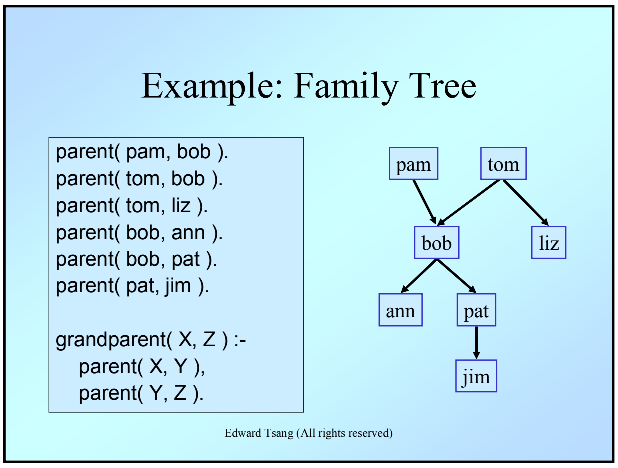


Queries Answering in Prolog

```
?-  father(john, jane).
yes
?-  father(john, Who).
Who = adrian
yes
?-  female(mary).
No
```

<< Demo program and explain how Prolog answers queries during lecture >>

- Prolog returns the first answer that it can find
  - Instantiating variables if needed
- Prolog answers answers by "walking a tree"
  - Essential to know
  - See textbook for details
- Prolog only returns answers according to the rules only
  - It answers "no" when it cannot *prove* something w.r.t. the facts and rules

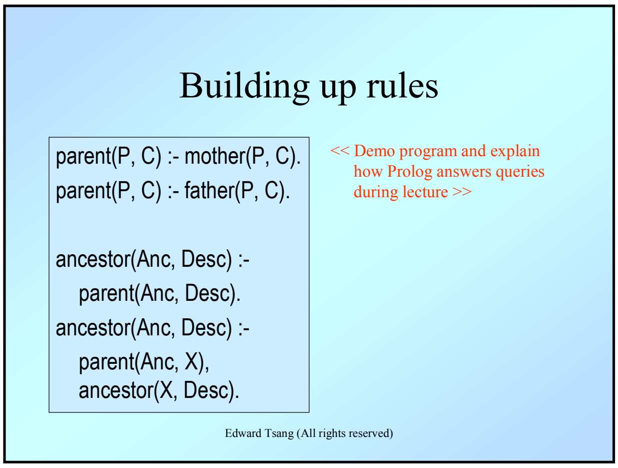


Example: Family Tree

```
parent( pam, bob ).
parent( tom, bob ).
parent( tom, liz ).
parent( bob, ann ).
parent( bob, pat ).
parent( pat, jim ).

grandparent( X, Z ) :-
   parent( X, Y ),
   parent( Y, Z ).
```

pam
tom
bob
liz
ann
pat
jim

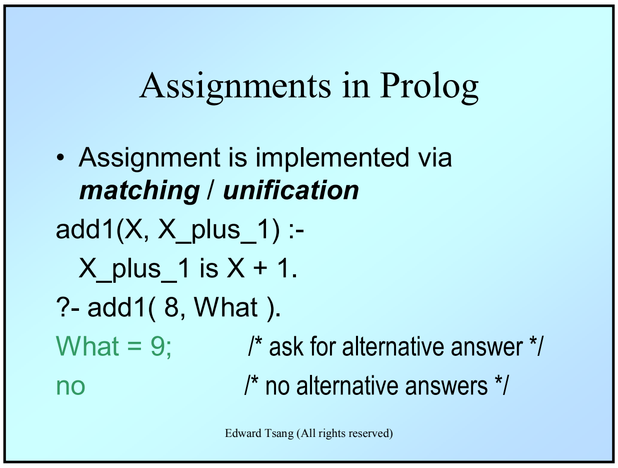


Building up rules

```
parent(P, C) :- mother(P, C).
parent(P, C) :- father(P, C).

ancestor(Anc, Desc) :-
   parent(Anc, Desc).
ancestor(Anc, Desc) :-
   parent(Anc, X),
   ancestor(X, Desc).
```

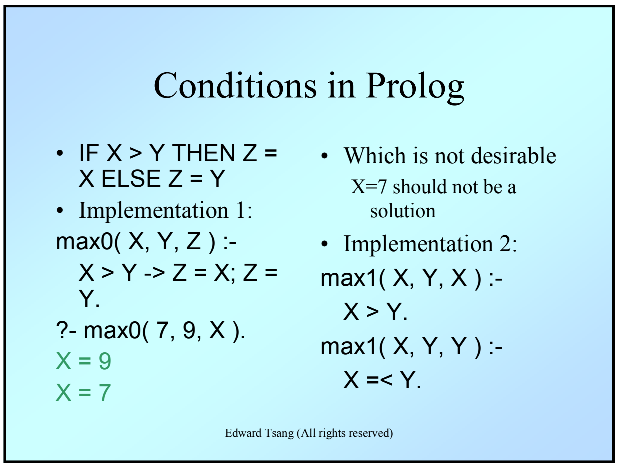
<< Demo program and explain how Prolog answers queries during lecture >>



Assignments in Prolog

- Assignment is implemented via ***matching* / *unification***

```
add1(X, X_plus_1) :-
   X_plus_1 is X + 1.
?- add1( 8, What ).
What = 9;        /* ask for alternative answer */
no               /* no alternative answers */
```



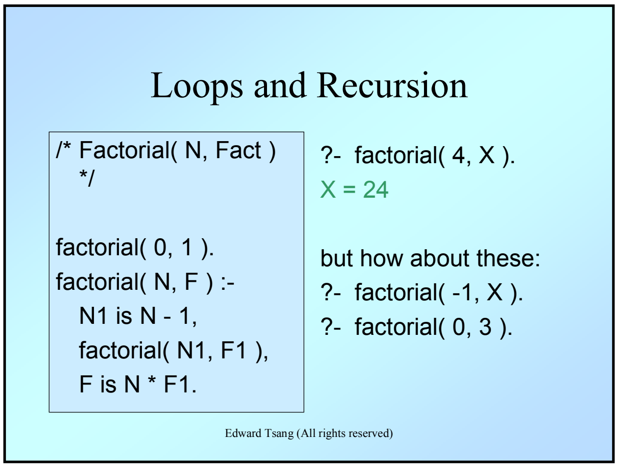
Conditions in Prolog

- IF X > Y THEN Z = X ELSE Z = Y
- Implementation 1:

```
max0( X, Y, Z ) :-
   X > Y -> Z = X; Z =
   Y.
?- max0( 7, 9, X ).
X = 9
X = 7
```

- Which is not desirable
  X=7 should not be a solution
- Implementation 2:

```
max1( X, Y, X ) :-
   X > Y.
max1( X, Y, Y ) :-
   X =< Y.
```



Loops and Recursion

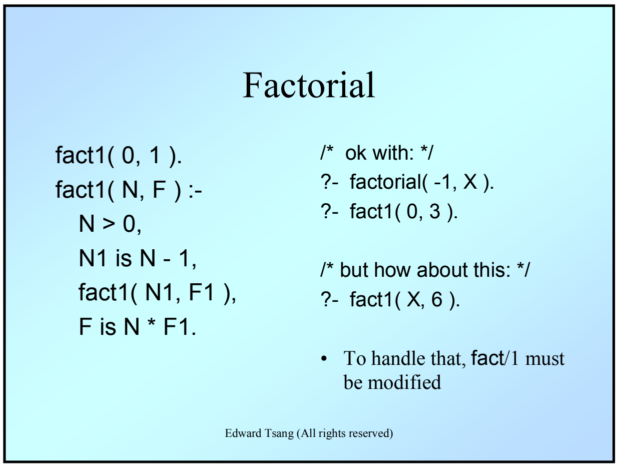
```
/* Factorial( N, Fact )
   */

factorial( 0, 1 ).
factorial( N, F ) :-
   N1 is N - 1,
   factorial( N1, F1 ),
   F is N * F1.
```

```
?-  factorial( 4, X ).
X = 24
```

but how about these:

```
?-  factorial( -1, X ).
?-  factorial( 0, 3 ).
```



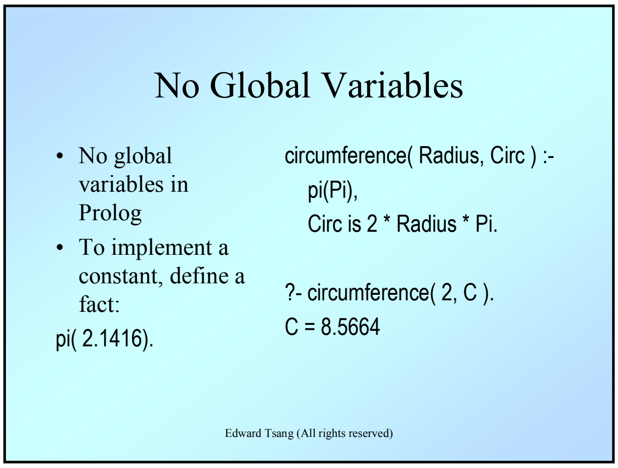
Factorial

```
fact1( 0, 1 ).
fact1( N, F ) :-
   N > 0,
   N1 is N - 1,
   fact1( N1, F1 ),
   F is N * F1.
```

```
/*  ok with: */
?-  factorial( -1, X ).
?-  fact1( 0, 3 ).

/* but how about this: */
?-  fact1( X, 6 ).
```

- To handle that, fact/1 must be modified



No Global Variables

- No global variables in Prolog
- To implement a constant, define a fact:

```
pi( 2.1416).
```

```
circumference( Radius, Circ ) :-
    pi(Pi),
    Circ is 2 * Radius * Pi.

?- circumference( 2, C ).
C = 8.5664
```

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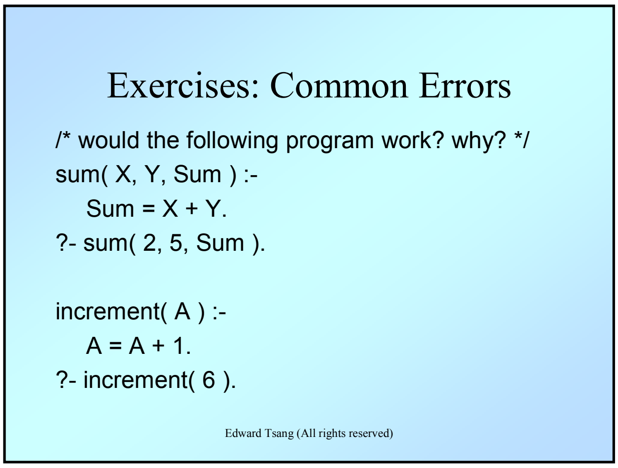

Exercises: Common Errors

```
/* would the following program work? why? */
sum( X, Y, Sum ) :-
    Sum = X + Y.
?- sum( 2, 5, Sum ).

increment( A ) :-
    A = A + 1.
?- increment( 6 ).
```

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