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CS1112
Bad Arguments:
Translation and Other Issues

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Translation, and other issues

Translating into logic

Contrapositive
Converse
Inverse

Logical Fallacies

Specifying systems

- specifying the behaviour of complex systems is a fundamental skill for computer science professionals
  - specifying access to computer systems
  - specifying desired behaviour for a software module
  - specifying a protocol for two programs to communicate
- Logic is the main technique for capturing and analysing such specifications
- If we can get the specification written in a logical form, then we have a chance of analysing it, establishing when an implementation meets a specification, or determining what solutions are allowed by the specification

Example system specifications

- You can read this web page if you are a computer science student

- You can read this web page if you are coming from a UCC IP address or if you can supply a password

- You can enter new data if the database is not being updated and if you have given the correct password

- If the email is from a blacklisted address or the email contains the word viagra and the sender is not in the local address book then the email is filtered to the Spam folder

Translating from English to conditional statements

We may translate sentences of the following type using $p \rightarrow q$:

- if p then q
- p implies q
- p only if q
- p is sufficient for q
- q follows from p
- q whenever p
- q when p
- q is necessary for p

Note that p and q have switched places

BUT BEWARE!
(i) you still need to check that this is what was meant
(ii) it is not safe to translate from logic into English if you use terms like "implies", "follows from", "is sufficient for", etc.

Exercise

Write the following statements using the conditional connective:

- If I work hard, I will pass CS1112
- Bribing the bouncer is sufficient to get into this nightclub
- The economy suffers whenever the Blue party is elected
- Road accidents follow from driving too fast
- The microwave beeping implies the food is cooked
- Wearing a tie is necessary for getting into this nightclub

Problems of translating from English

- Our use of the English language is not precise
- When translating from English into logic, you must ensure you have captured the intent of the original sentence
- Three main problems:
  - unclear precedence and association
  - inclusive vs exclusive OR
  - conditional sentences
- Example: "if you don't eat your main course, then you can't have any pudding"
  - translate this into logic – does the logical formula match what the speaker meant, or what the child expected?

Example

Represent "You can read this page if you are a CS student"

Let p = "you can read this page"
Let q = "you are a CS student"

$$\boxed{q \rightarrow p}$$

And now analyse it. Is it what we meant by the sentence?

q	p	$q \rightarrow p$	
T	T	T	You are a CS student and you can read the page ✓
T	F	F	You are a CS student and you can't read the page ✗
F	T	T	You are not a CS student and you can read the page ?
F	F	T	You are not a CS student and you can't read the page ?

Example

Represent
"If the email is from a blacklisted address or the email contains the word viagra and the sender is not in the local address book then the email is filtered to the Spam folder"

Example

We know the following facts about a network:

- if we are receiving sensor data, then the relay node is working
- if the relay battery is low, the relay node does not work

Can we prove that if the relay battery is low then we do not receive sensor data?

Represent this using propositional statements, and prove the conclusion using rules of inference and logical equivalences.

The contrapositive

¬q→¬p   is called the contrapositive of p→q

$(p \rightarrow q)$ **?** $(\neg q \rightarrow \neg p)$

p	q	$p \rightarrow q$	$\neg q$	$\neg p$	$\neg q \rightarrow \neg p$
T	T	T			
T	F	F			
F	T	T			
F	F	T			

$(p \rightarrow q) \equiv (\neg q \rightarrow \neg p)$

A conditional statement is true <u>if and only if</u> its contrapositive is true

The converse

$q \rightarrow p$ is called the converse of $p \rightarrow q$

$$(p \rightarrow q) \ \textbf{?} \ (q \rightarrow p)$$

p	q	$p \rightarrow q$	q	p	$q \rightarrow p$
T	T	T			
T	F	F			
F	T	T			
F	F	T			

$$(p \rightarrow q) \not\equiv (q \rightarrow p)$$

A conditional statement is NOT logically equivalent to its converse

The inverse

$\neg p \rightarrow \neg q$ is called the inverse of $p \rightarrow q$

$(p \rightarrow q)$? $(\neg p \rightarrow \neg q)$

p	q	$p \rightarrow q$	$\neg p$	$\neg q$	$\neg p \rightarrow \neg q$
T	T	T			
T	F	F			
F	T	T			
F	F	T			

$(p \rightarrow q) \not\equiv (\neg p \rightarrow \neg q)$

A conditional statement is NOT logically equivalent to its inverse

Conditional statements and equivalents

A condition statement $p \rightarrow q$ is equivalent to:

- $\neg p \vee q$
- its contrapositive $\neg q \rightarrow \neg p$

but is NOT equivalent to

- its converse $q \rightarrow p$
- its inverse $\neg p \rightarrow \neg q$

Statement: "If I am in Cork, then I am in Ireland"

converse I am in Ireland, then I am in Cork" **different**

? "Either I am not in Cork or I am in Ireland" **equivalent**

inverse 'If I am not in Cork, then I am not in Ireland" **different**

contrapositive not in Ireland, then I am not in Cork" **equivalent**

Logical Fallacies

- a logical fallacy is a bad argument – in other words, a sequence of statements that do not guarantee that the conclusion is true whenever the premises are true.

- Sadly, logical fallacies are everywhere
  - in politicians' statements
  - in articles in newspapers
  - in casual conversations

- Learn to spot them
  - you will be able to tell when someone is conning you
  - ... and you will become a better computer scientist

Examples of fallacies

- *Affirming the consequent:*
  $p \rightarrow q$ is true and q is true, therefore p is true

NOT VALID

Example: If I am at work, then I am wearing a tie.
I am wearing a tie.
Therefore I am at work.

- *Denying the hypothesis*:
  $p \rightarrow q$ is true and p is false, therefore q is false

NOT VALID

Example: If I click on dodgy links, I will be infected by a virus.
I do not click on dodgy links.
Therefore I will not be infected by a virus

Examples of fallacies (continued)

- *Affirming the disjunct:*
  $p \vee q$ is true and p is true, therefore q is false

NOT VALID

Example: It will either rain today or the sun will shine
It rained today
Therefore the sun did not shine.

(This type of argument only works if the "OR" is exclusive. But in propositional logic, we normally assume that OR is inclusive. You need to think carefully before translating any English sentence.)

CS1112: clear and precise specification, reasoning and communication

THE END

Algorithms: specifying complex processes

Sets: specifying and reasoning about collections of objects

Functions: specifying transformation processes from one collection of objects to another

Relations: specifying general relationships between collections of objects

Propositional Logic: precise communication, specification and reasoning, based on truth functions

Next lecture ...

examples and exercises

Another way of verifying an argument

Build a new statement, consisting of the conjunction of the premises, the conditional connective, and the conclusion. If the resulting formula is a tautology, the argument is valid.

p	q	$p \to q$	$p \wedge (p \to q)$	$(p \wedge (p \to q)) \to q$
T	T	T	T	T
T	F	F	F	T
F	T	T	F	T
F	F	T	F	T

tautology