COGS 200: Introduction to Cognitive Systems

Bob Woodham

Department of Computer Science
University of British Columbia

Lecture Notes 2014/2015 Term 1

14W1: September–December, 2014

Readings Summary

Papert, Seymour. (1988). “One AI or many?” *Daedalus* 117(1)1-14

- Papert is not a neutral party in the connectionist debate
- Papert addresses, “the nature of artificial intelligence and its appeal to people more interested in the human mind than in building robots”
- Papert speaks of “psychologically relevant” saying, “Artificial intelligence should become the methodology for thinking about ways of knowing”
- Papert urges us to attend to the requirements of specific kinds of tasks, not to the search for universal mechanisms
- Papert argues that what can (and can not) easily be done by parallel and distributed machines is technically non trivial to sort out. The qualities parallel and distributed “are in tension rather than sweet harmony”
- For systems that need to interact with (and survive in) the real world, time often is an important task constraint

Today's Learning Goals

1. To provide examples that demonstrate the challenges that dealing with time raise in computer science
2. To understand causality and the difference between causal (i.e., "on-line") and acausal (i.e., "off-line") computation
3. To understand scalability, here taken to mean how the time complexity of a computation grows with the size of the problem considered
4. To begin to explore constraints on embodied robotic systems so that they can interact with (and survive in) the real world

Example 1: Concurrency and Resource Contention

Contrast:

(1.1) John reviewed the paper, played the piano, and vacuumed the floor; he had no time left to cook dinner

(1.2) John sprawled on the sofa, read a magazine, and listened to music; he had lots of time left to cook dinner

Gerevini, 1997

Example 2: Time Dependent Knowledge

Complete the following:

Example 2: Time Dependent Knowledge

Complete the following: “God save the ____________”

Example 2: Time Dependent Knowledge

Complete the following: “God save the ______________”

Top ten in the line of succession to Queen Elizabeth II

1. Prince Charles, Prince of Wales
2. Prince William, Duke of Cambridge
3. Prince George of Cambridge
4. Prince Henry of Wales
5. Prince Andrew, Duke of York
6. Princess Beatrice of York
7. Princess Eugenie of York
8. Prince Edward, Earl of Wessex
9. James Mountbatten-Windsor, Viscount Severn
10. Lady Louise Mountbatten-Windsor

Example 3: Truth Maintenance

Suppose a red object A is near a blue object B. Suppose a robot picks up object A and moves it to a different location

Question: How does the robot "know" that object A is no longer near object B?

Question: How does the robot "know" that object A still is red and object B still is blue?

Answer: A robot doesn't "know" that movement typically alters nearness but preserves colour unless this is represented in the robot's internal model of the world

Alternative answer: A robot (with vision) doesn't need an internal model of the world. If it needs to reason further about colour or nearness, it can always look. That is, let the world be its own model

Time in Distributed Systems

"A system is distributed if the message transmission delay is not negligible compared to the time between events in a single process."

Leslie Lamport,
"Time, Clocks, and the Ordering of Events in a Distributed System,"
Communications of the ACM 21(7)558–565, 1978

Time in Distributed Systems

> *"A system is distributed if the message transmission delay is not negligible compared to the time between events in a single process."*

Leslie Lamport,
"Time, Clocks, and the Ordering of Events in a Distributed System,"
Communications of the ACM 21(7)558–565, 1978

Corollary: All (non trivial) systems these days are distributed systems

Time in Distributed Systems (cont'd)

- Time (in the large):
  - networks of computers, GPS
  - reservation systems
  - stock trading
  - on-line shopping

Time in Distributed Systems (cont'd)

- Time (in the small):
  - clock skew
  - (multi-core) clock synchronization
- Time (in the large):
  - networks of computers, GPS
  - reservation systems
  - stock trading
  - on-line shopping

Time in Distributed Systems (cont'd)

- Time (in the small):
  - clock skew
  - (multi-core) clock synchronization
- Time (in the large):
  - networks of computers, GPS
  - reservation systems
  - stock trading
  - on-line shopping
- Time (in the very large):
  - outside on a sunny day
  - outside on a starry night

Aside: CBC Time Signal

November 5, 2014, marked the 75th anniversary of the National Research Council's official time signal, broadcast on CBC radio

> *"To determine the official time, the NRC uses atomic clocks, which are instruments that use microwave signals and atoms to provide the most accurate time known in the world. . .*
> *. . . They probably gain only a few microseconds in a year. . .*
> *. . . The NRC also sends out a time signal through the Network Time Protocol, which is what's used to set time on most personal computers"*

The beginning of the long dash indicates. . .

Newton-Raphson

Let $f(x)$ be a function defined over the real numbers, x, with derivative $f'(x)$. A root of $f(x)$ is a value of x for which $f(x) = 0$

Let x_0 be a first guess for a root of $f(x)$. Provided the function satisfies certain assumptions, a better approximation, x_1, is given by

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

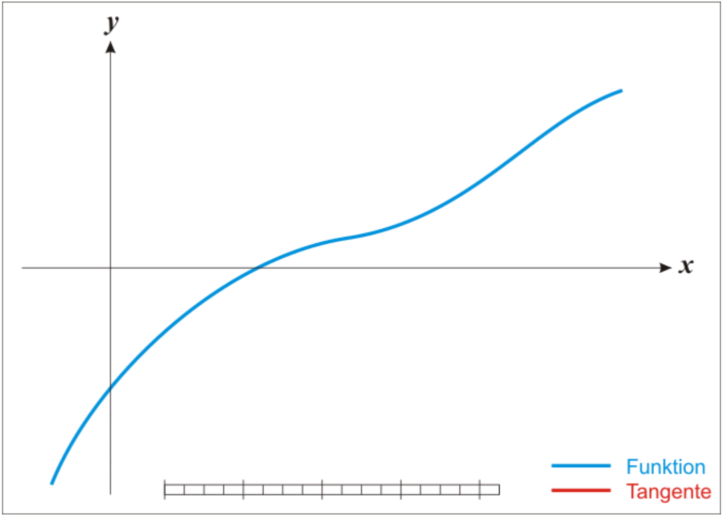
The process is repeated as

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

until a sufficiently accurate value is reached

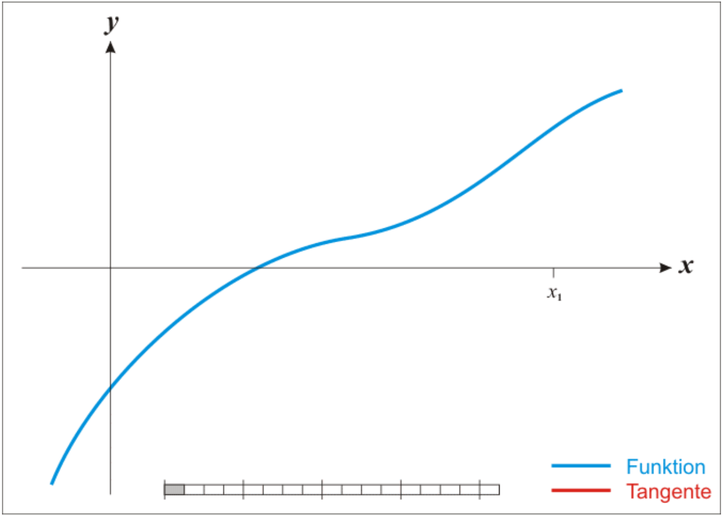
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



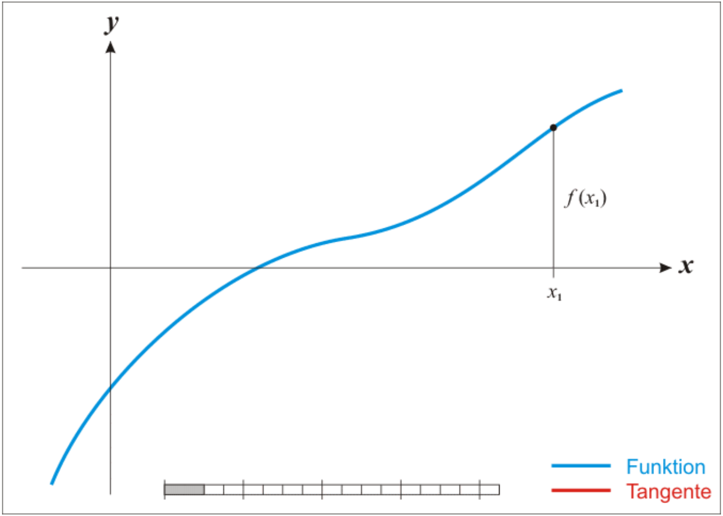
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



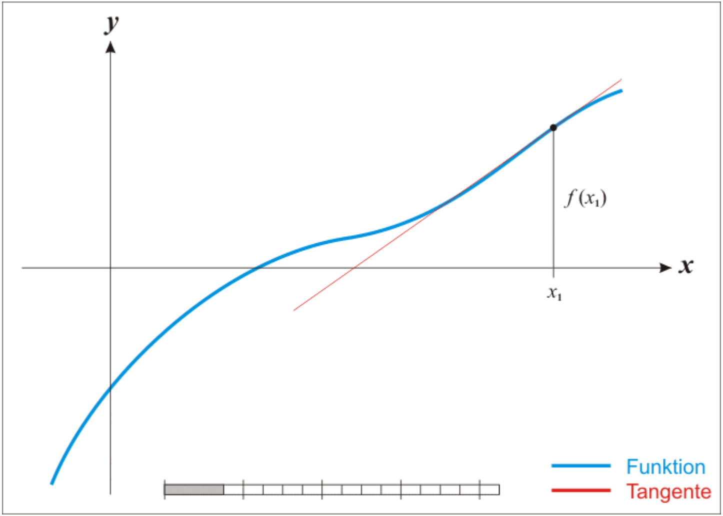
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



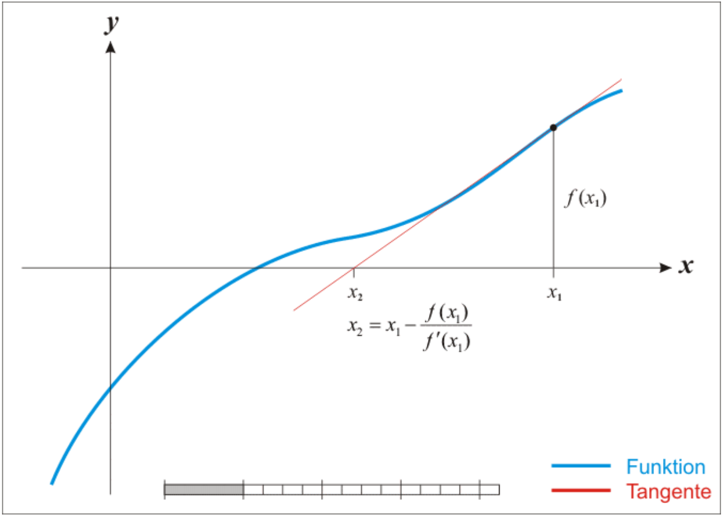
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



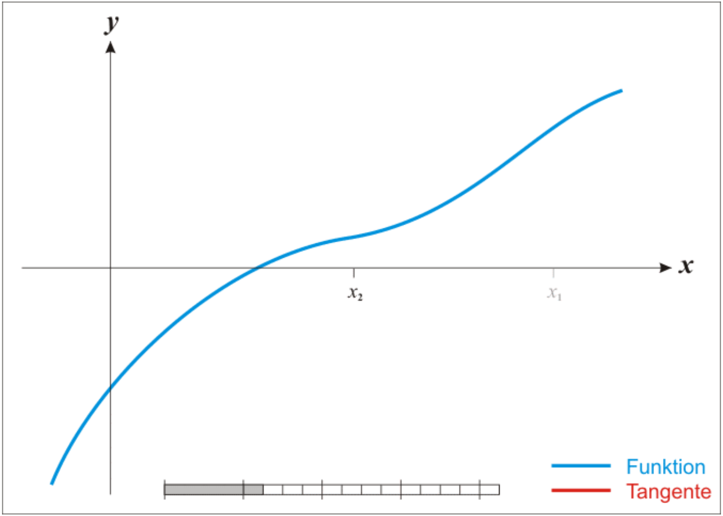
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



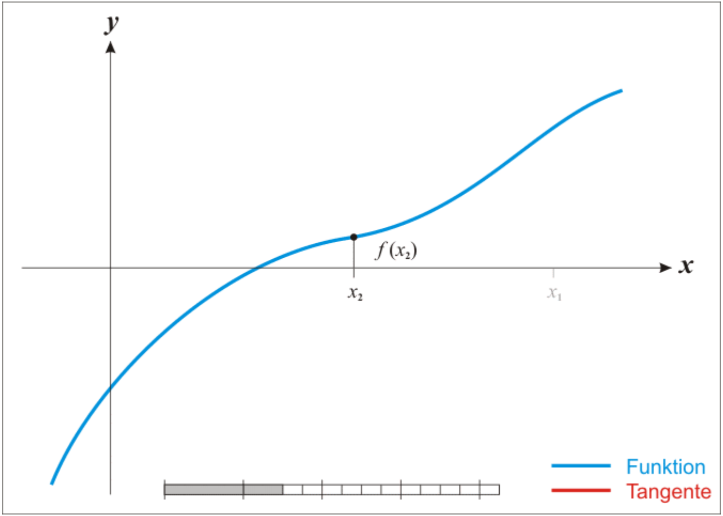
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



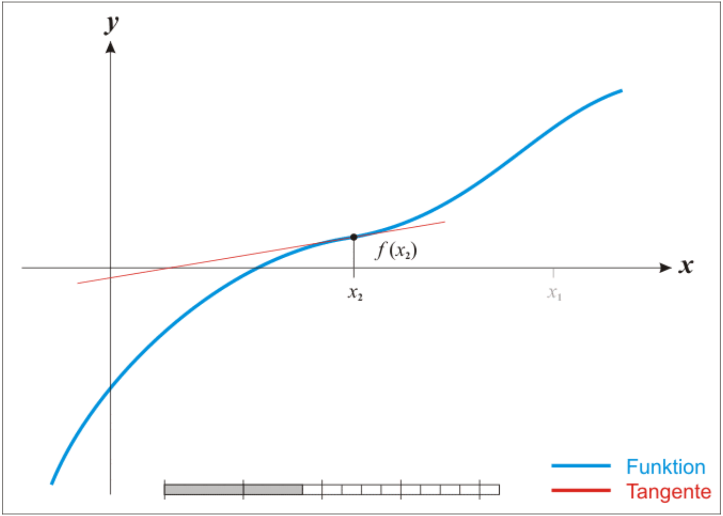
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



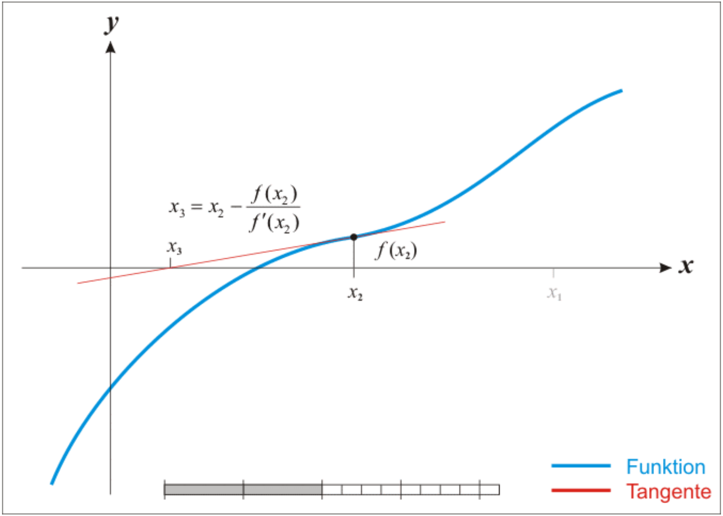
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



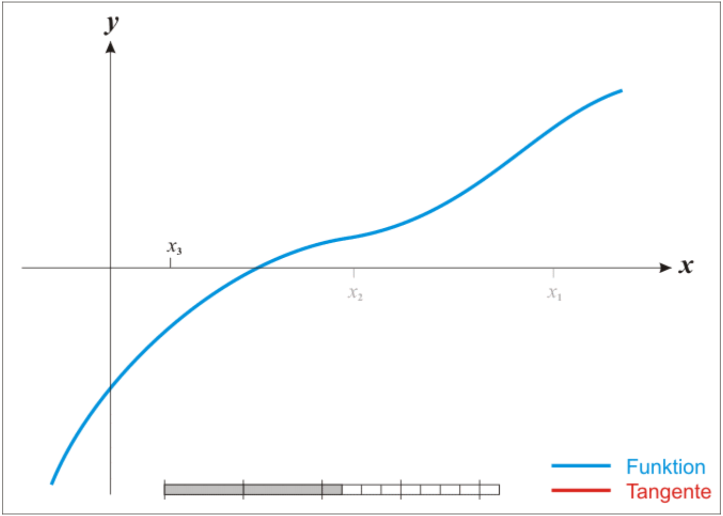
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



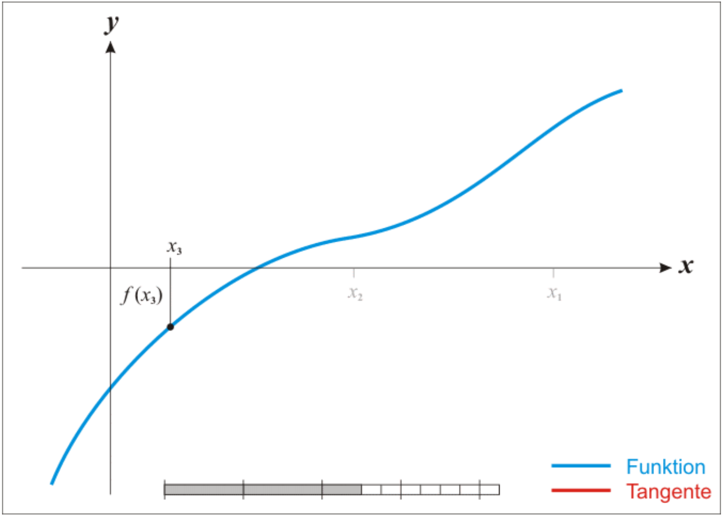
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



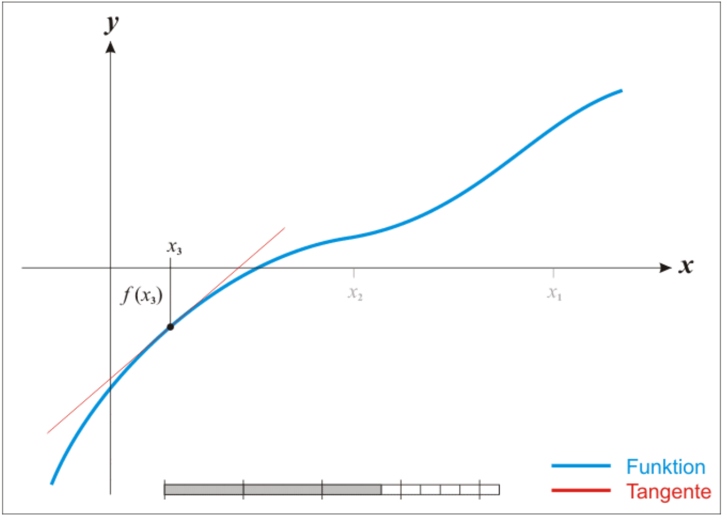
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



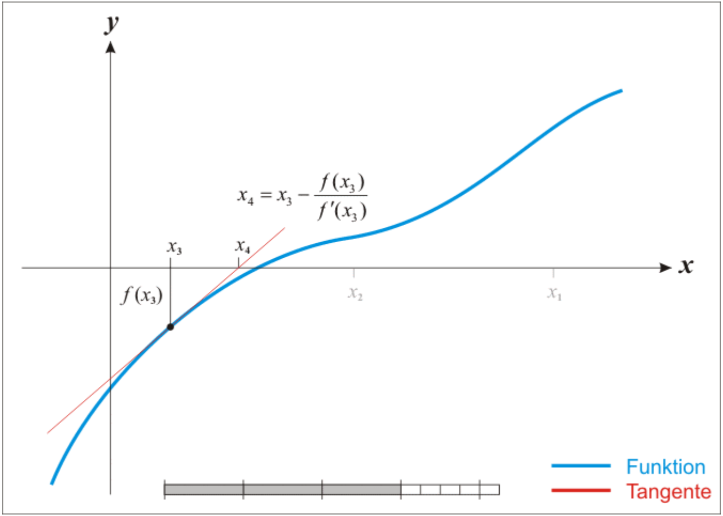
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



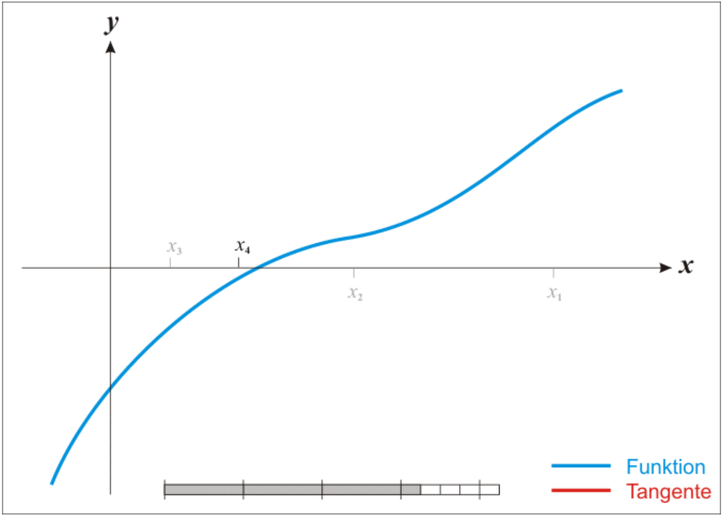
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



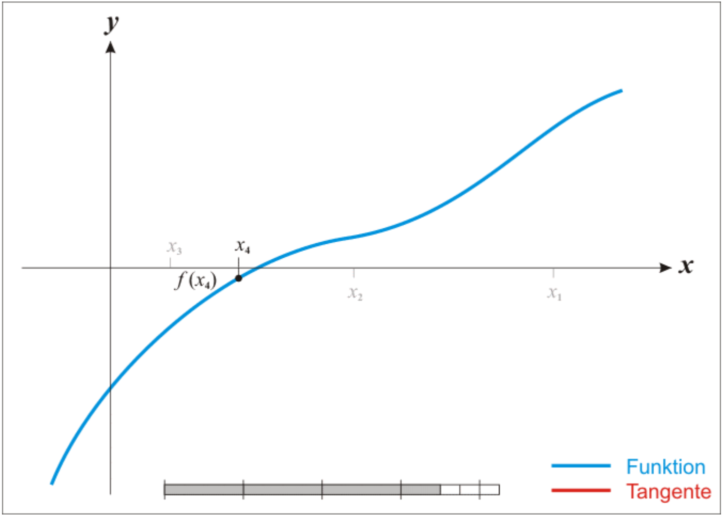
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



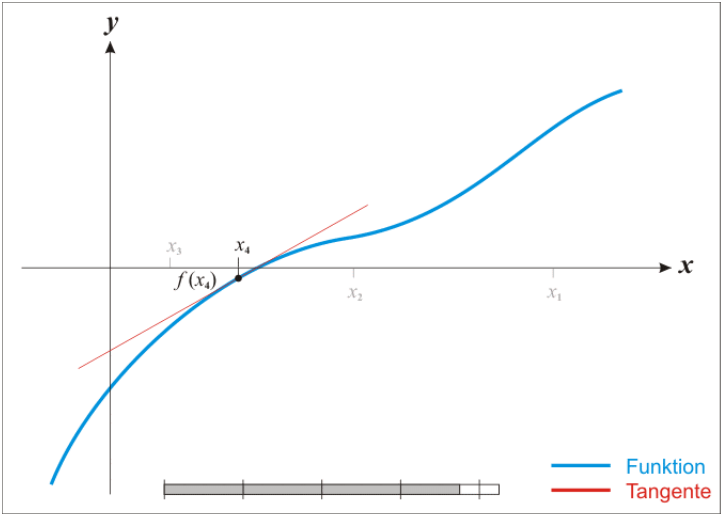
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



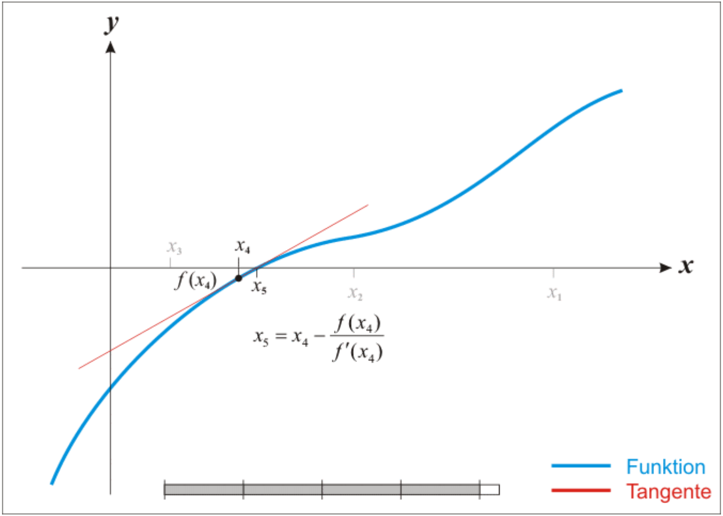
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



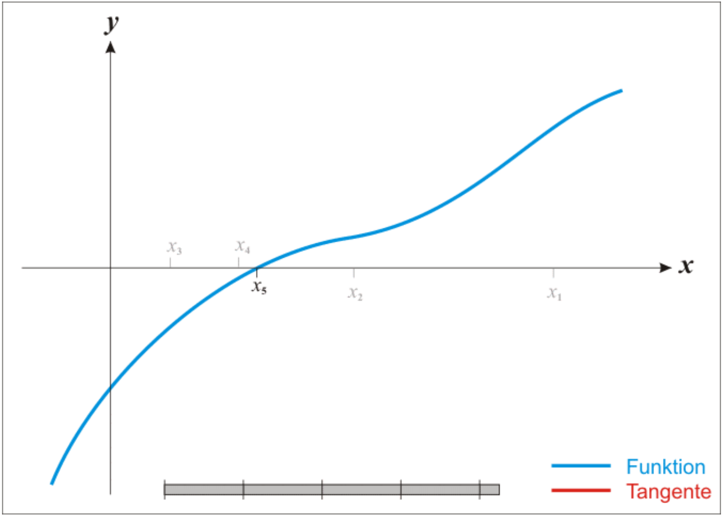
http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



http://en.wikipedia.org/wiki/Newton%27s_method

Newton-Raphson (Geometric Interpretation)



http://en.wikipedia.org/wiki/Newton%27s_method

Example 4: Newton-Raphson $\sqrt{2}$

The value of $\sqrt{2}$ (55 digit precision) is:

1.414213562373095048801688724209698078569671875376948073

With Newton-Raphson and an initial guess of 1.5, we obtain

Iteration	Estimate	Digits Accuracy
0	1.5	1
1	1.41666666666666666666666666666666...	3
2	1.41421568627450980392156862745098...	6
3	1.41421356237468991062629557889013...	12
4	1.41421356237309504880168962350253...	24
5	1.41421356237309504880168872420969...	48
⋮	⋮	⋮

Example 5: You be the Judge

The BC provincial government, fearful that there aren't enough lawyers in the province, decides to launch a new private (but accredited) law school named, "Suits 'R Us University." In order to entice students, Suits 'R Us offers the following guarantee to its graduates, "Win your first case or your tuition is free"

Ariel, a COGS alumna, decides to enrol. Law school turns out to be easy for her and she graduates with a high GPA. Suits 'R Us accountants notice, however, that despite repeated letters of reminder and even referral to a collection agency, Ariel never paid any tuition

Suits 'R Us proceeds to sue Ariel for the tuition owing. Ariel represents herself in this her first case. The case comes before the judge

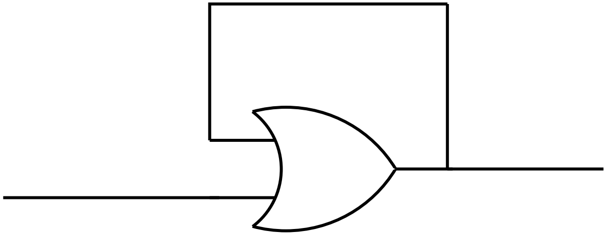
Example 5 (cont'd): You be the Judge

The lawyer for Suits 'R Us approaches the judge and argues, "Your honour, this case is simple. Suits 'R Us is suing for payment of tuition. If you rule in our favour then Ariel must pay. Should you rule in Ariel's favour then she has won her first case. Thus, according to the terms of her agreement with Suits 'R Us, she owes us tuition. Either way, Ariel must pay"

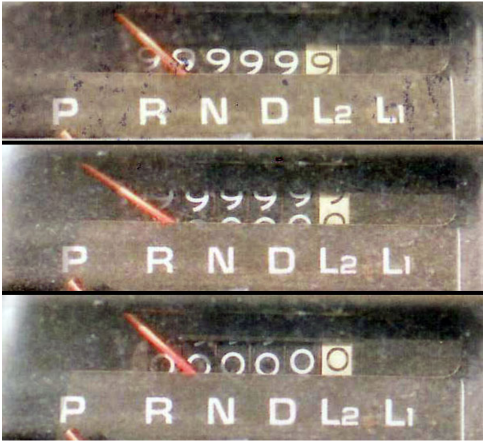
Ariel approaches the judge. She says, "Your honour, I agree with my learned opponent that the case is simple. Unfortunately, opposing counsel has it quite wrong. Suits 'R Us is suing me for payment of tuition. If you rule in my favour then, according to that ruling, I don't have to pay. Should you rule in favour of Suits 'R Us then I will have lost my first case. Thus, according to the terms of the guarantee, I don't have to pay. Either way, I don't have to pay"

Question: How does the judge rule?

What about this?



Example 6: Odometer Problem



http://en.wikipedia.org/wiki/Odometer

Example 7: Toll Booth Problem

Consider an automated automobile toll booth. The gate is normally closed. When a driver makes the appropriate payment, the gate opens to let that automobile proceed. There is no human to decide when to open and close the gate

Question: How long should the gate stay open?

Too Long: Multiple cars can proceed through the gate on a single payment

Too Short: The gate can come down before the car that payed has proceeded through the gate or worse, it can come down on top of the car causing damage (and delays)

Example 7 (cont'd): MIT 6.004 Solution

The entire "Flakey Control Signals" sequence shown in class is posted on UBC Connect

Example 8: Puck Location and Possession

Andrew Duan's M.Sc thesis (August, 2011) added the automatic determination of puck location and possession into the UBC LCI sports video analysis system

Here's what Andrew's system does with one test hockey video sequence:

Note: The 1000 frame broadcast hockey sequence shown in class is not embedded in the slides

Credit: Xin Duan (Andrew)
Additional credits: Kenji Okuma, Wei-Lwun Lu, Ankur Gupta

Today's Learning Goals

1. To provide examples that demonstrate the challenges that dealing with time raise in computer science
2. To understand causality and the difference between causal (i.e., "on-line") and acausal (i.e., "off-line") computation
3. To understand scalability, here taken to mean how the time complexity of a computation grows with the size of the problem considered
4. To begin to explore constraints on embodied robotic systems so that they can interact with (and survive in) the real world