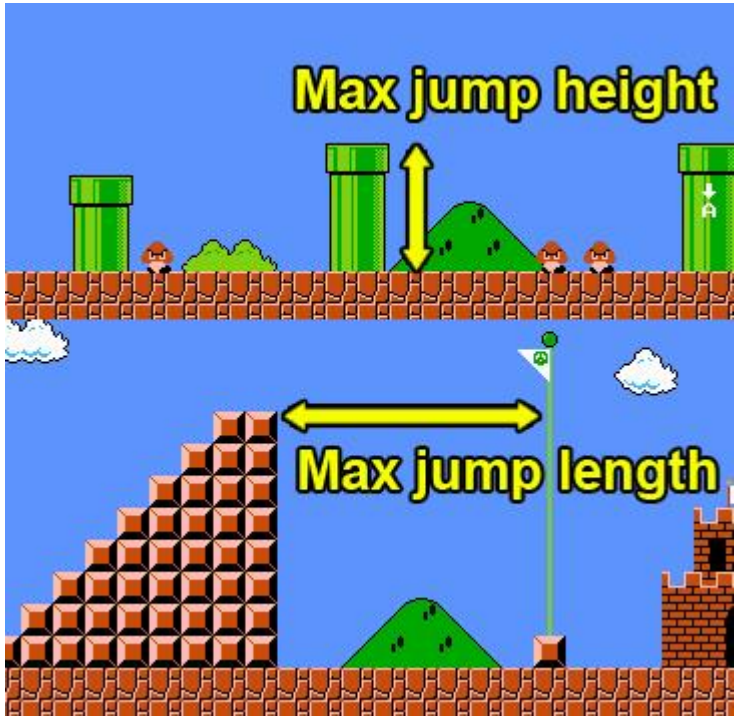
Helge Rhodin

CPSC 427
Video Game Programming

Game Balancing

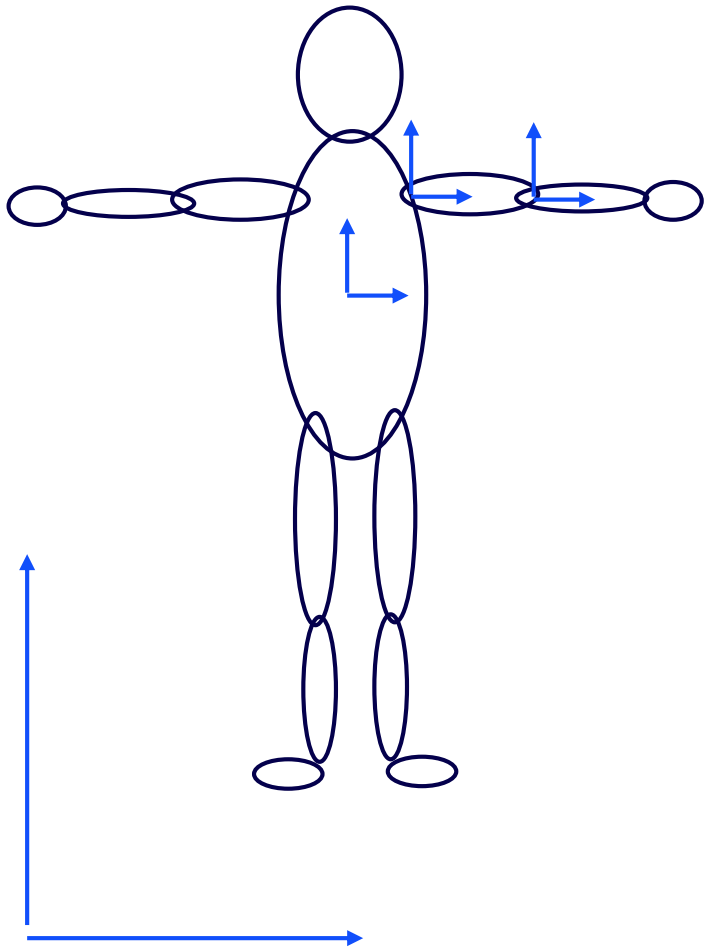


Setup

@Helge: Pressed record?

@Class: Logged into iClicker cloud?

Recap: Transformation Hierarchies



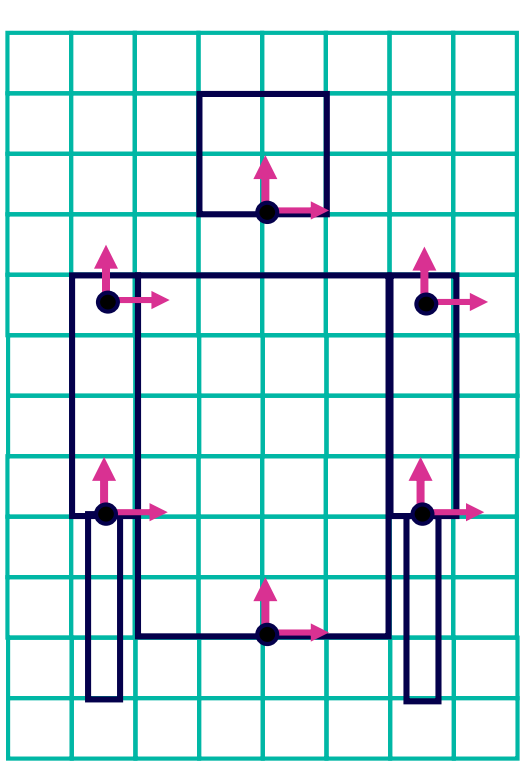
Scenes have multiple coordinate systems

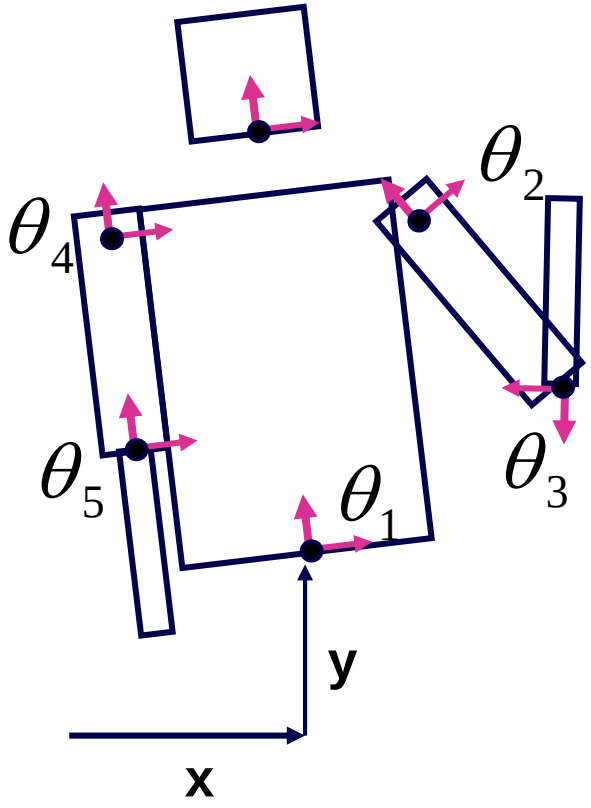
- Often strongly related
  - *Parts of the body*
  - *Object on top of each other*
    - Next to each other…

Independent definition is bug prone

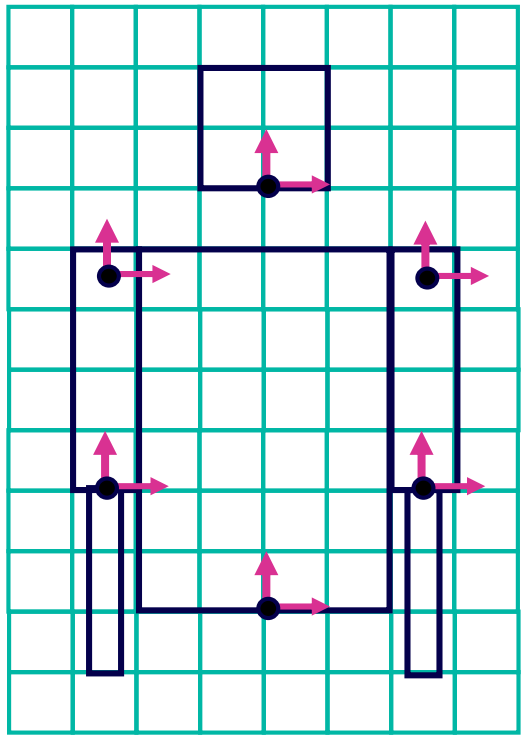
Solution: Transformation Hierarchies

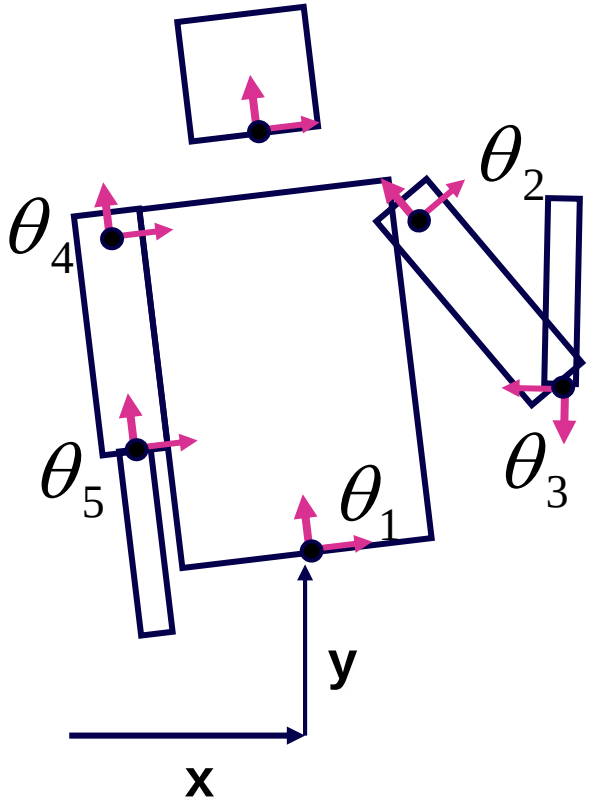
Recap: Transformation Hierarchy Examples





Recap: Transformation Hierarchy Examples



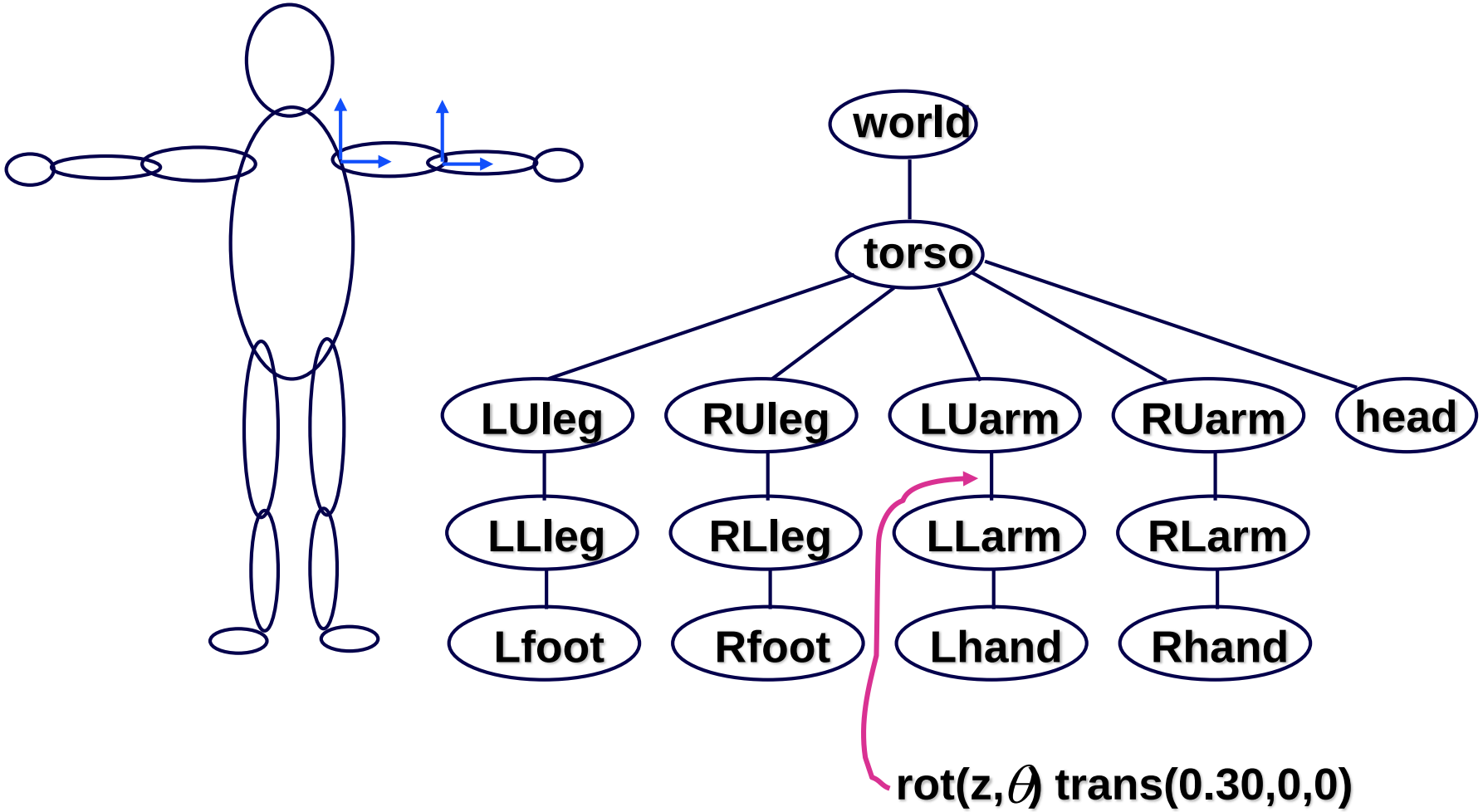


$$M_1 = Tr_{(x,y)} \cdot Rot\theta_1$$

$$M_2 = M_1 \cdot Tr_{(2.5,5.5)} \cdot Rot\ \theta_2$$

$$M_3 = M_2 \cdot Tr_{(0,-3.5)} \cdot Rot\ \theta_3$$

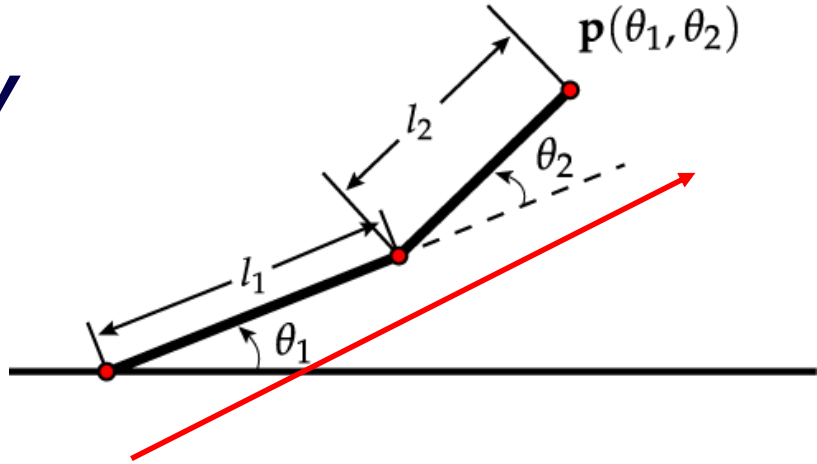
Recap: Transformation Hierarchies



Recap: Forward vs. inverse kinematics

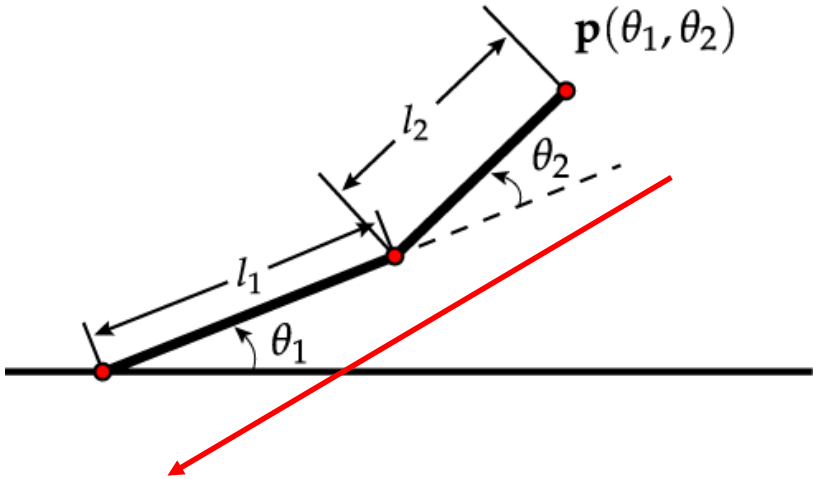
Forward kinematics

- ***given joint axis, angle, and skeleton hierarchy***
- ***compute joint locations***
  - *start at the end-effector (e.g. arm)*
    - rotate all parent joints (up the hierarchy) by θ
  - *iteratively continue from child to parent*



Inverse kinematics

- given skeleton hierarchy and goal location
- optimize joint angles (e.g. gradient descent)
- minimize distance between end effector (computed by forward kinematics) and goal locations

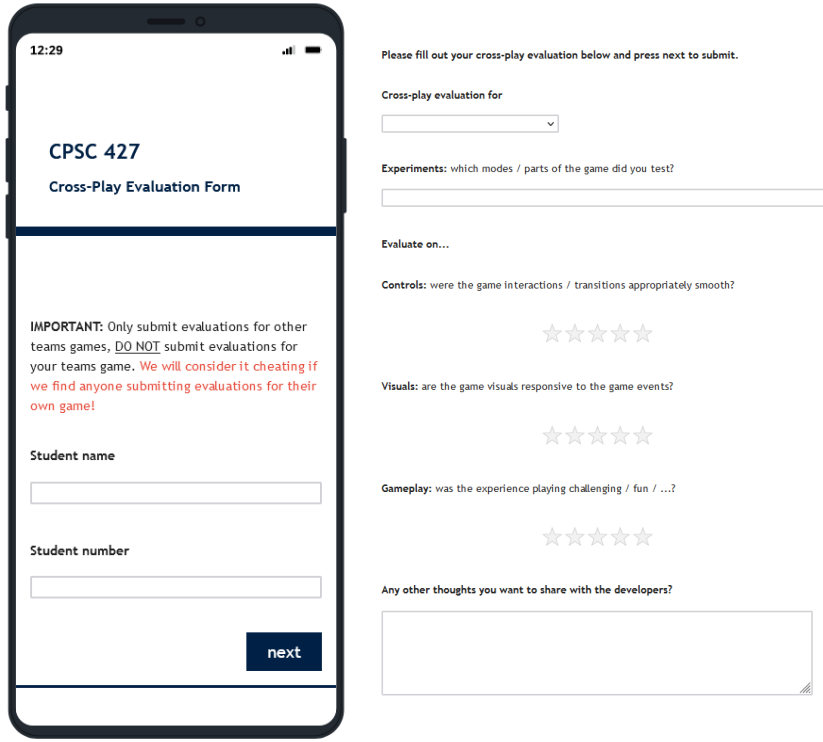


Cross-play

- ***Short lecture until ~3:30 pm***

- ***Cross-play***
  - starting at ~3:30 pm
  - four rounds, each (15 min):
    - *A plays B's game (5-7min)*
      and also B plays A's game (5-7 min)
  - fill out feedback form after each play (5 min)

- https://piazza.com/class/krpu7s953e6wt?cid=363



Team Presentations

- ***Showcase your game (live or video)***
- ***Share one thing that worked well***
- ***Share one thing that did not work/took longer***

Update slides here:

https://docs.google.com/presentation/d/1vN4NcaJvd015AyxZ0GVFnPeu1EaYMlSU0_XAEwsc4ts/edit?usp=sharing

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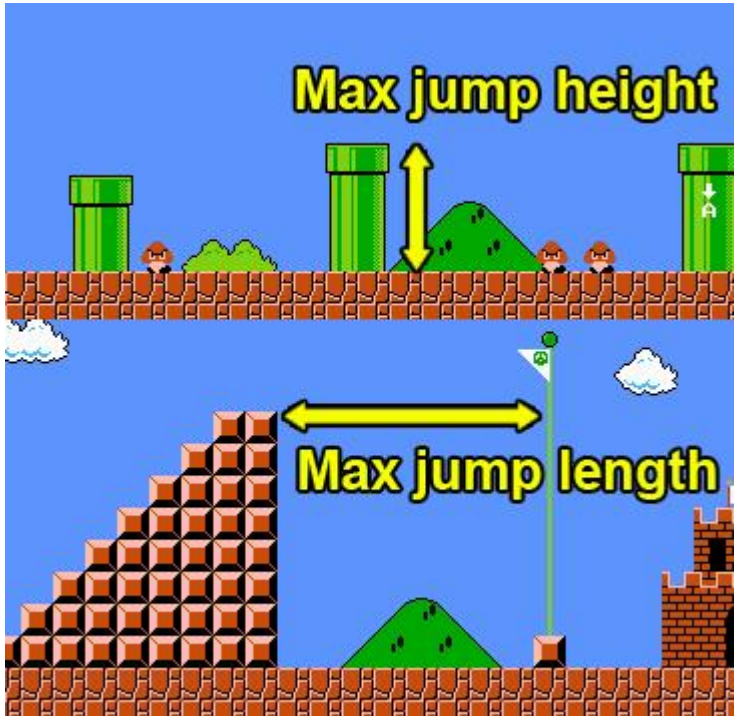
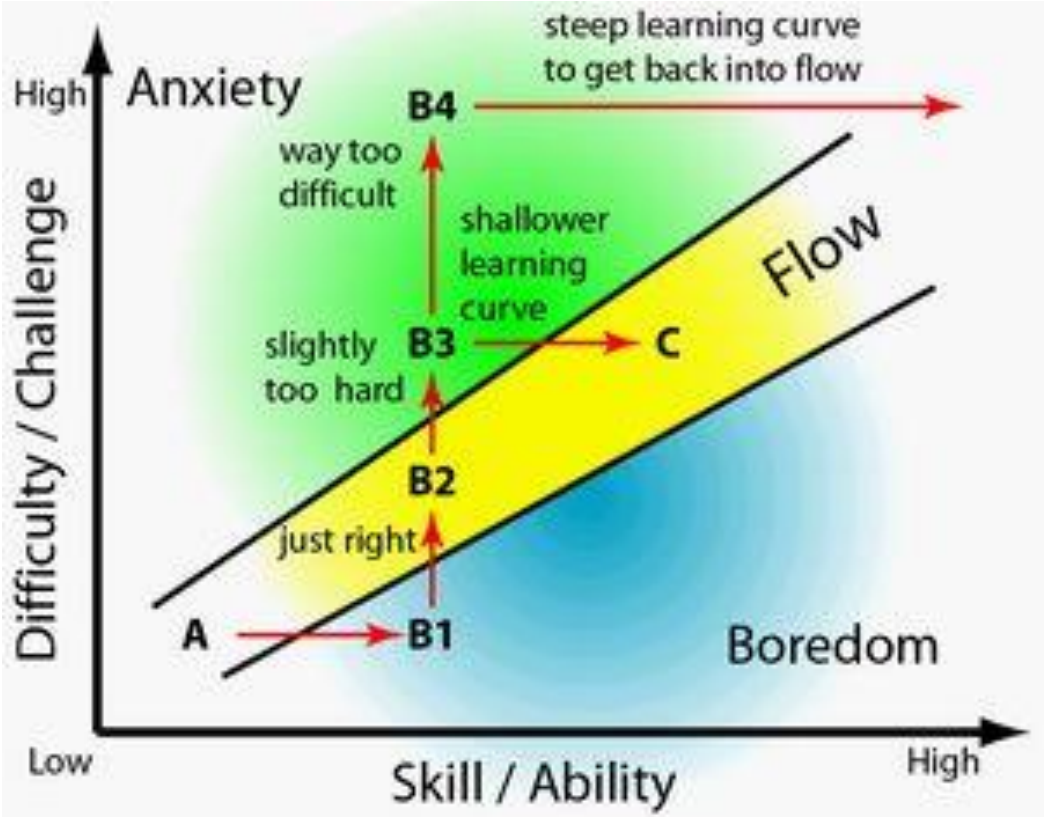


Fun to play?



https://www.androidauthority.com/level-design-mobile-games-developers-make-games-fun-661877/

Learning goals

- ***Know the different aspects of a game that can be balanced.***
- ***Connecting game balancing to game theory***
- ***Learn about common balancing steps***
- ***Practice basic game balancing***

Resources on Balancing

https://gamebalanceconcepts.wordpress.com/2010/07/07/level-1-intro-to-game-balance/

by Ian Schreiber

What does balanced mean?

- *Is chess balanced?*
- *Settlers of Catan?*
- *Is Tetris balanced?*
- *Is your game balanced?*

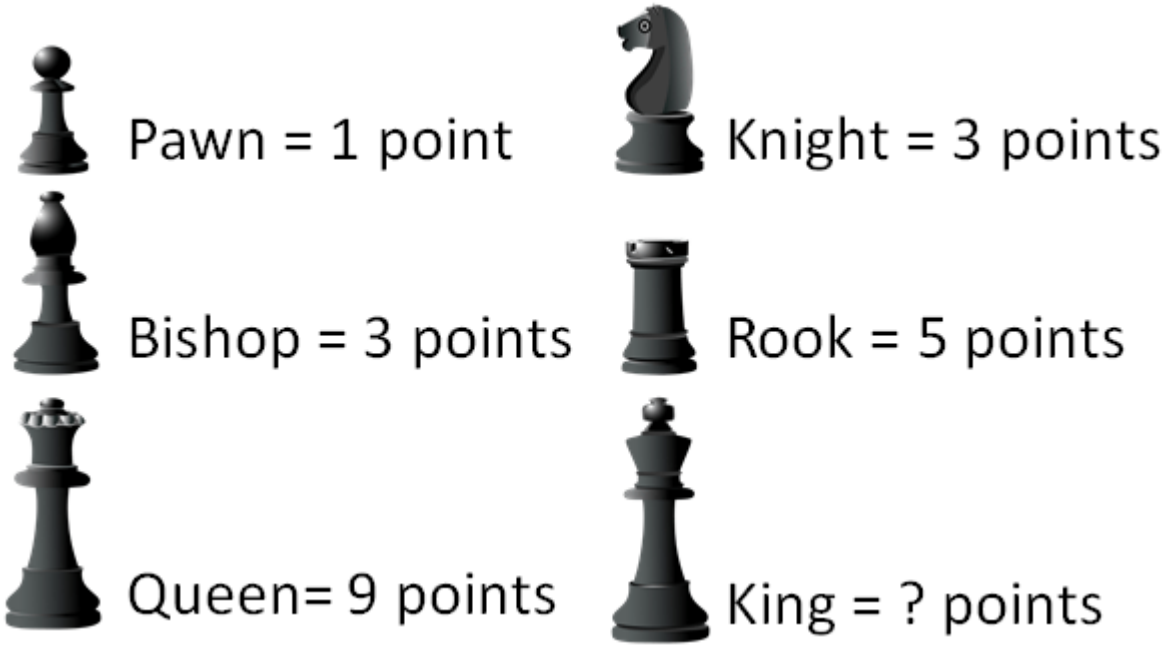
Modeling

Indirect relationships

Value of a piece

- *it is not possible to get a knight for 3 pawns*
- *one can 'trade' pieces*
- *a currency*

How to determine?

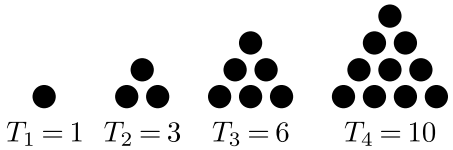


Numeric quantities

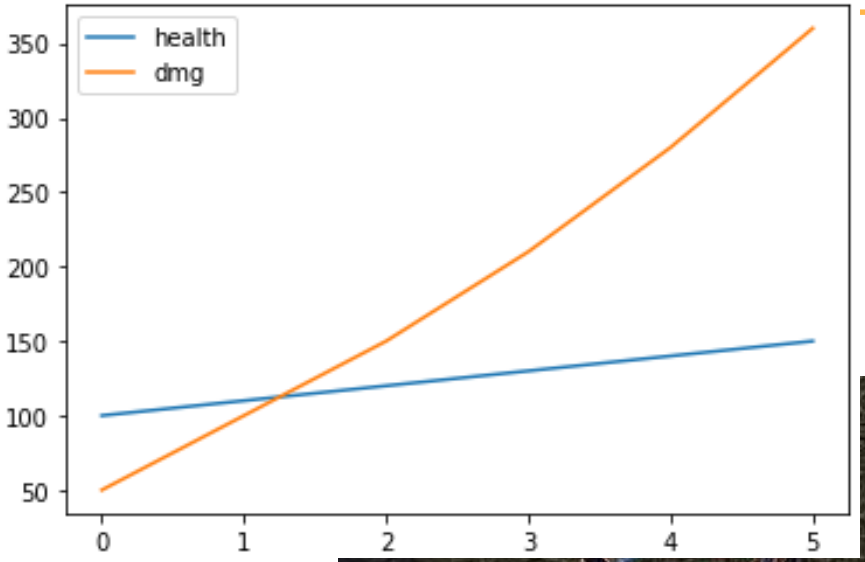
- ***Values in your game?***

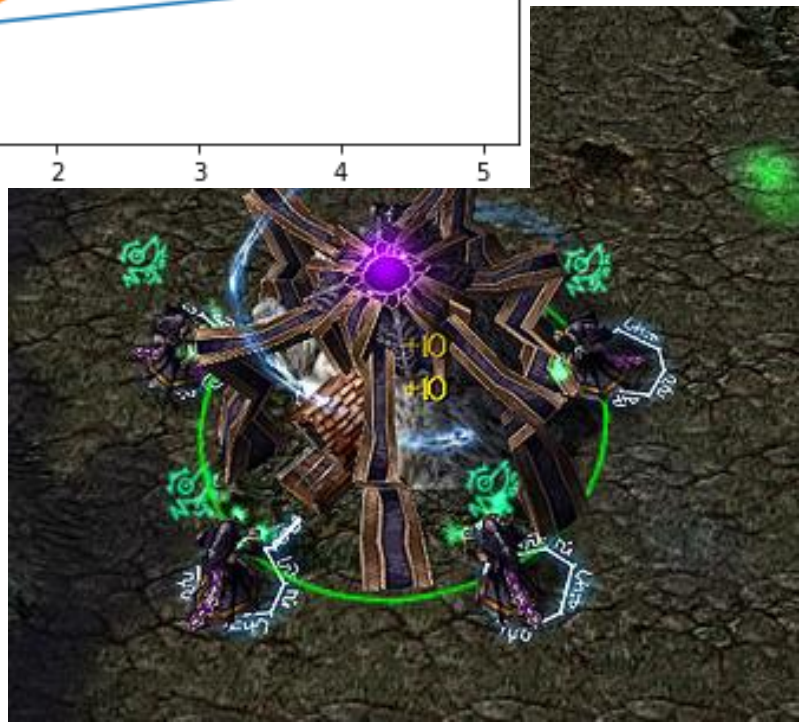
Relationships

- ***Linear relations***
- ***Exponential relations***
- ***Triangular relationship***
  - 1, 3, 6, 10, 15, 21, 28, …



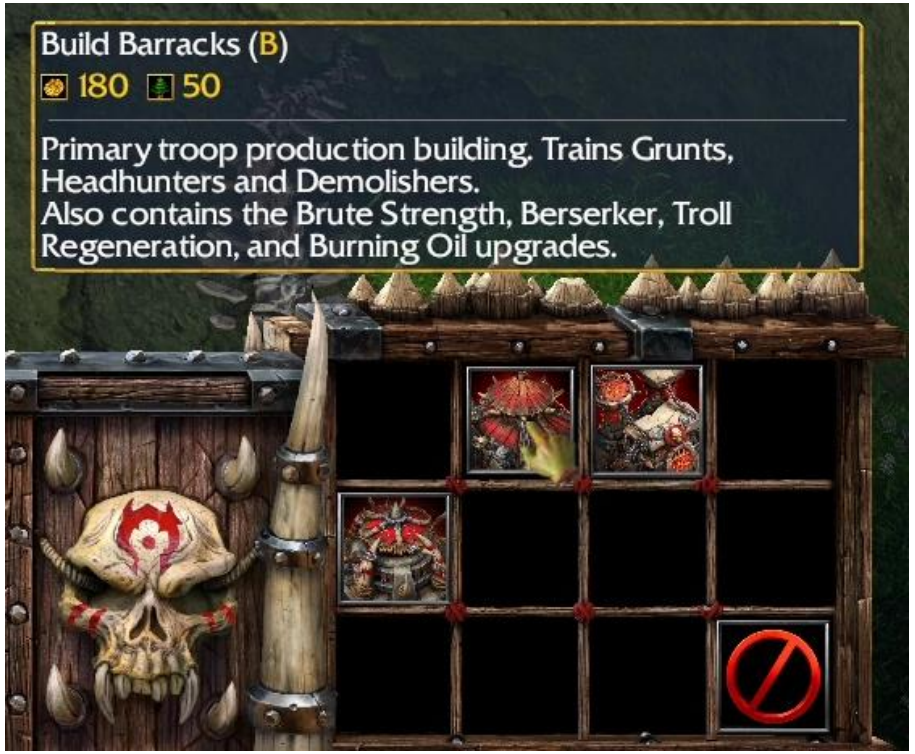
  - The difference increases linearly
  - The function has quadratic complexity
- ***Periodic relations***
  (summer, winter, …)





Model interactions between relationships

- *2x item A + 1x item B = 5x item C*
- *Attack speed * damage = damage / second*
- *Buff: 2x health or +100 health*
  - *what is better?*
- *Progression:*
  - *XP -> level up -> new skill -> ?*

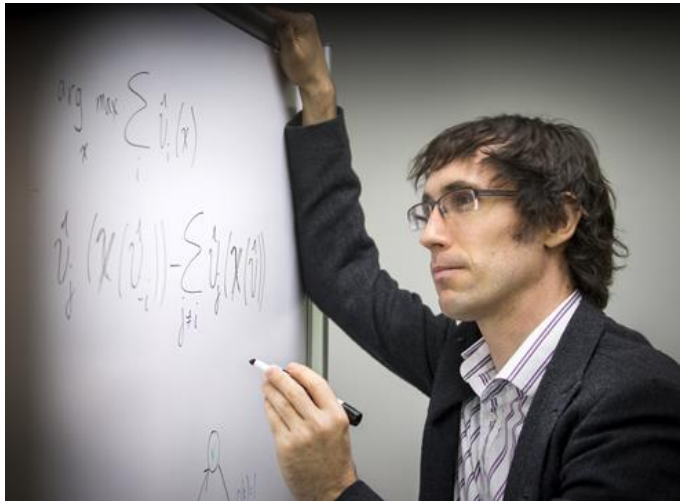


Game Theory

A mathematical concept

- *Used for trading, road design, …*

Interested?



Kevin Leyton-Brown

Terminology

- **Dominant strategy**: one path that is stronger than all others
- **Fairness**: equal chances to win
- **Nash equilibrium:** each player's strategy is optimal when considering the decisions of other players

Important Considerations

- ***Determinism vs. randomness***
- ***Solvability***
  - *Has a best/dominant strategy*
    - Is this desirable?
  - *Can you solve a non-deterministic game?*

- ***Intransitive games***
  - simultaneous choice between opponents, e.g. *Rock-Paper-Scissors*
- ***Symmetric***
  - *same chances*
- ***Game and meta game***

Learning goals

- ***Know the different aspects of a game that can be balanced.***
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Breakout

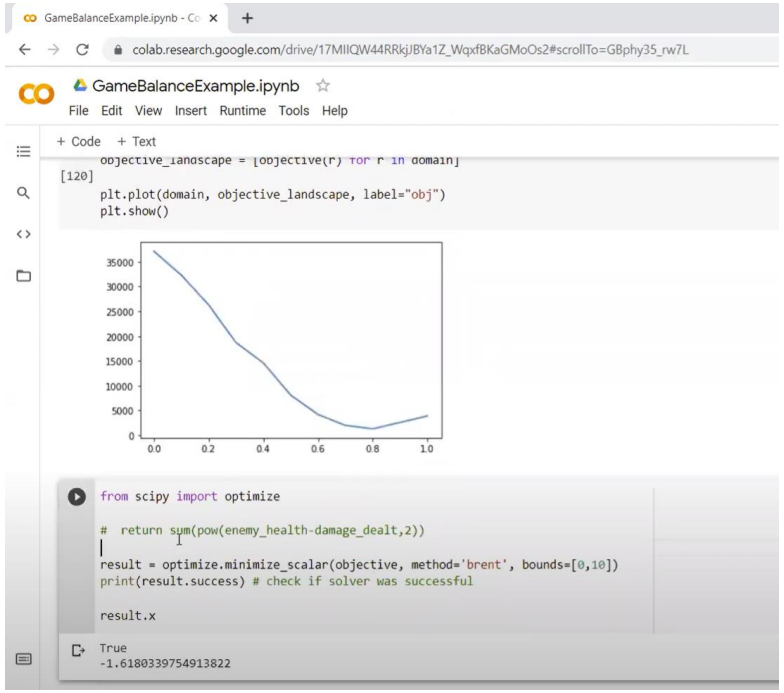
- ***List all relevant quantities in your game***
- ***List their relations:***
  - Type: e.g., linear
  - Quantitatively: e.g., +5 gold per round,
    1 gold = 100 silver

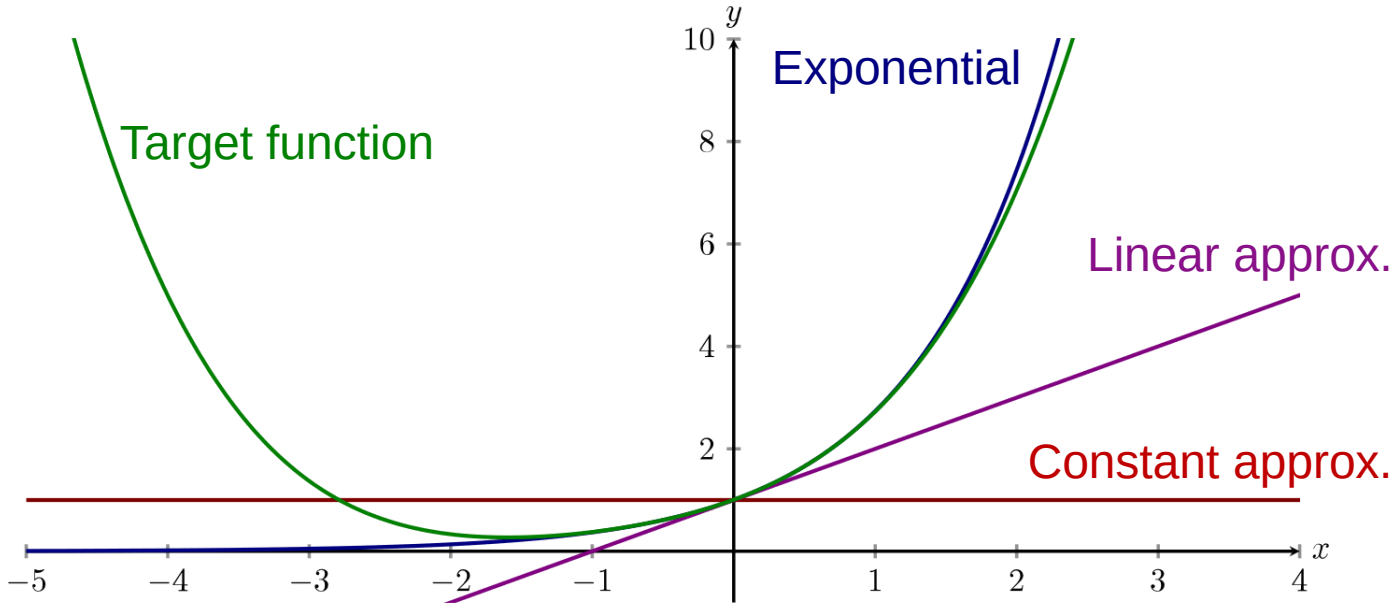
- *Investigate interactions between relations*
- ***What is your game's currency?***
  - *Gold, life, …?*

6 min
select representative to report

Self study? Numerical Methods - Optimization

- ***Iterative optimizers***
  - Single variable?
  - Multiple variables?
  - Gradient descent?





Lecture: https://youtu.be/ZNsNZOnrM50

- **Balancing demo starts at 1h20**
- **Optimizer used at ~ 1h30**

Learning goals

- ***Know the different aspects of a game that can be balanced.***
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Balancing example

- *10 enemies per level*
- *One tower does 1 damage / sec*
- *One tower costs 2 gold*
- *It takes enemies 10 seconds to pass*

- ***How much gold should the player start with?***

- ***Enemy health increases:*** *11,12,14,17,21,…*
- ***How much gold should the player get in round 2?***
- ***How much gold should each eliminated enemy give?***

Demo

Difficulties:

- ***Placement of towers changes the time damage is dealt***
- ***Path of enemies can be hindered to increase time***
- ➢ ***Measure during playtest***
  - ➢ *cross-play*
- ***Some enemies are resistant to fire/magic/…?***
  - *kind of a periodic feature*

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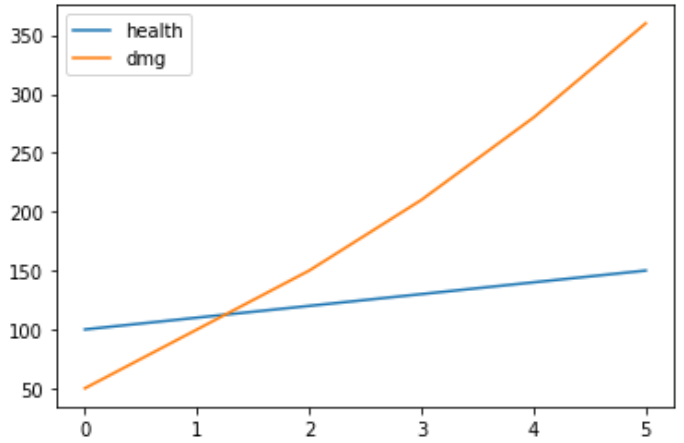
Counter Measures

- **Transitive Mechanics**
  - *Repair costs*
  - *Consumables (food, potions, …)*
  - *Tax*

Asymptotic analysis?

- *Linear * linear?*
- *Linear + linear?*
- *Linear + exponential?*
- *Linear * exponential?*



Formally, given functions $f(x)$ and $g(x)$, we define a binary relation

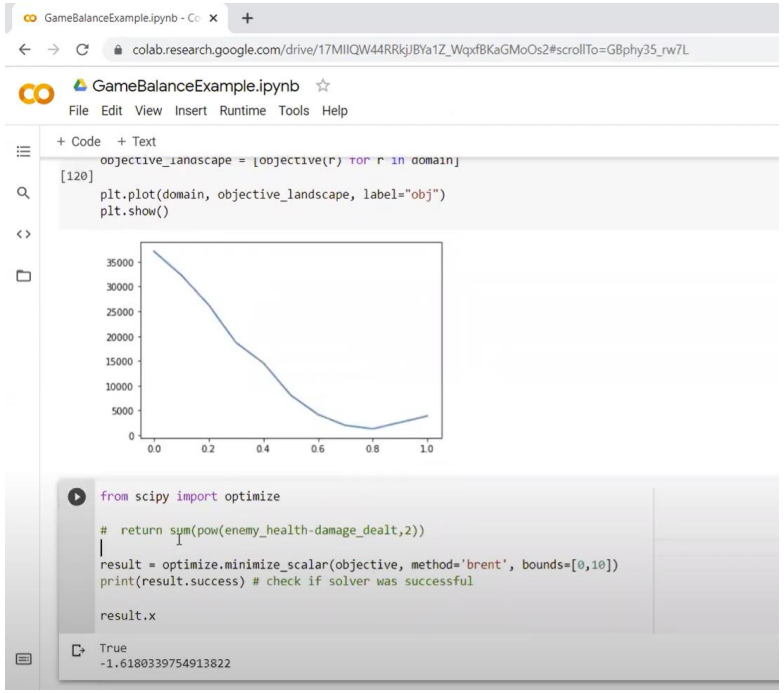
$$f(x) \sim g(x) \quad (\text{as } x \to \infty)$$

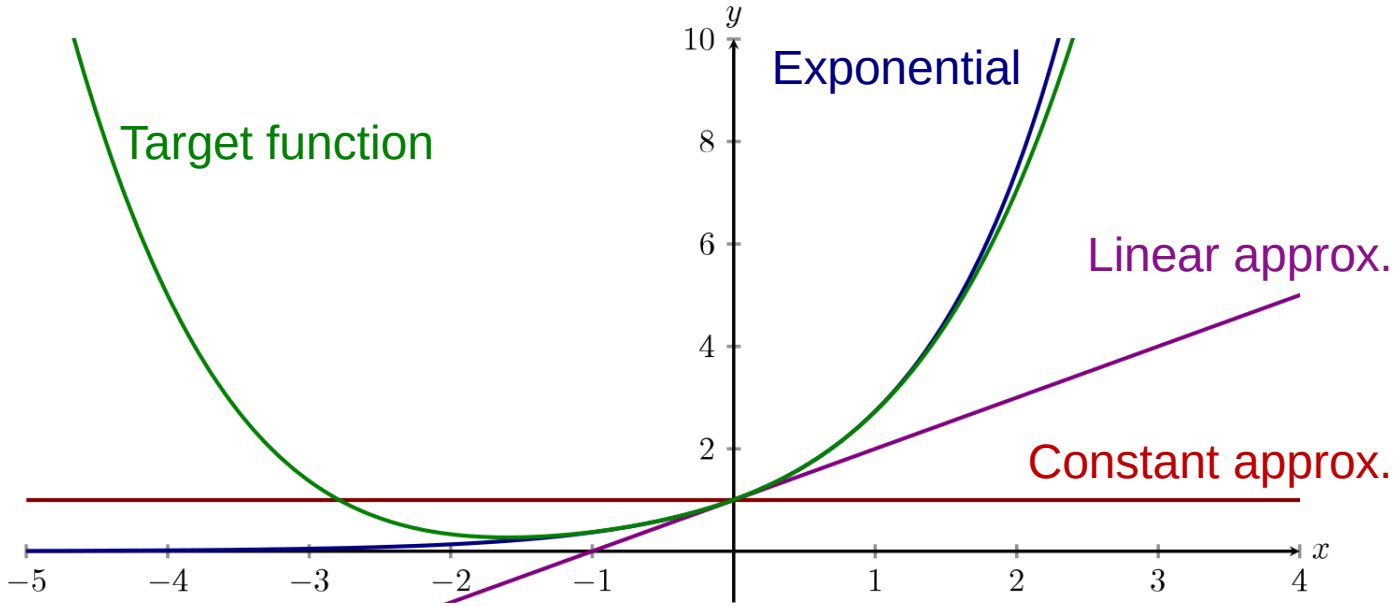
if and only if (de Bruijn 1981, §1.4)

$$\lim_{x \to \infty} \frac{f(x)}{g(x)} = 1.$$

Numerical Methods - Optimization

- ***Iterative optimizers***
  - Single variable?
  - Multiple variables?
  - Gradient descent?





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- **Balancing demo starts at 1h20**
- **Optimizer used at ~ 1h30**

How to quantify difficulty?

- ***Player vs. enemy strength***
- ***Likelihood of winning***
- ***Required skill***
  - *Knowledge of the game*
  - *Reaction*
  - *Precision*
  - *Tactics*

-> Estimate player strength in relation skill level: beginner, intermediate, pro?
-> requires user studies!

M4 balancing requirement

Carefully balance one aspect of your game (e.g., movement-speed, health points, strength, bonus,…).

- ***Report on the theoretical analysis***
- ***Change log with testing results (before/after balancing)***

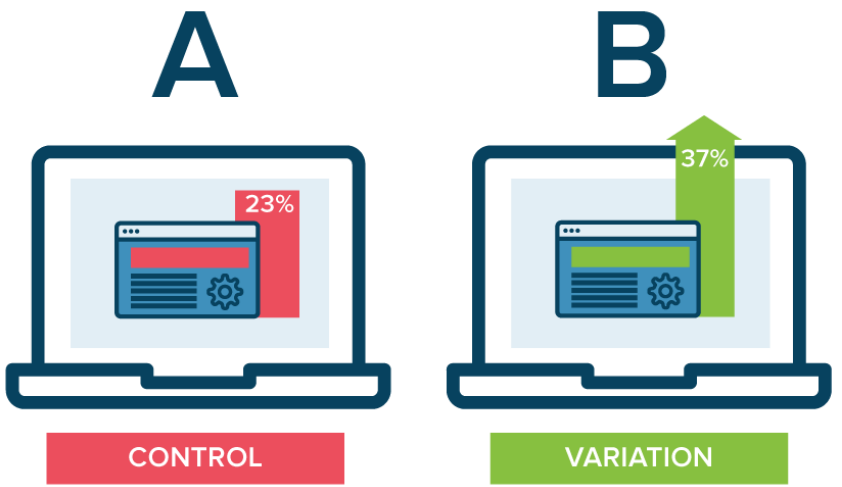
Breakout II

- ***Sketch progression***
  - *Quantities over time*
  - *Interactions between quantities*
- ***Use pen & paper, plotting tool, or python***
- ***Start balancing your game***

A/B Testing

Testing two variants of your game (with and w/o a feature)

- *randomized participants (same pool)*
- *with respect to a measurable objective (e.g., clicks on website)*



Related to

- two-sample hypothesis testing
- Clinical tests, e.g., testing of a COVID-19 vaccine
- Placebo effect

https://www.optimizely.com/optimization-glossary/ab-testing/