From *Rock, Paper, Scissors* to *Street Fighter II*: Proof by Construction

Yotam I. Gingold

new york university

mrl

Rock, Paper, Scissors
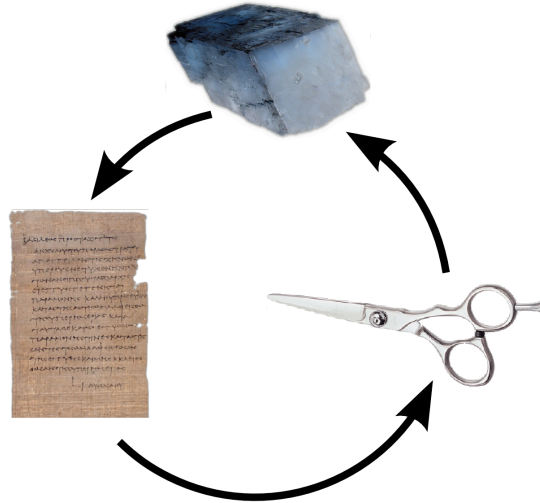
Two players choose, in secret, one of three choices and simultaneously present their choices to each other. Scoring is cyclic. Each presentation is a complete game, following Jesper Juul. The game can be extended to a series of matches, where the winner is whoever wins a majority of matches, say best 5 out of 7.

This game is often used as a tie-breaking scheme, but has an annual world championship.

Jesper Juul's definition of a game:

1. a rule-based formal system;

2. with variable and quantifiable outcomes;

3. where different outcomes are assigned different values;

4. where the player exerts effort in order to influence the outcome;

5. the player feels emotionally attached to the outcome;

6. and the consequences of the activity are optional and negotiable.

Same game, harder to understand. Also called Odds and Evens.

In addition, there are variants of RPS with 7, 9, 11, 15 and 25 choices, and variants that scale nicely for multiple players.

Game Theory

Optimal strategy is choosing randomly. On average, outcome is a draw.

you

		🪙	🪙
me	🪙	1,-1	-1,1
	🪙	-1,1	1,-1

new york university
mrl

No pure strategy -- at least one player would always change if he knew his opponent planned to do. The optimal strategy is to play randomly and guarantee a tie.

But random play isn't the best you can do against a player who isn't playing optimally (randomly); you can exploit patterns.

This is what computer players do.

There were computer-played tournaments held in 2000 and 2001. Random came in middle. But weaker players were exploited by stronger players, and the best computer player had a number of different prediction mechanisms competing with each other (he knows I know he knows I know, frequency) (including random)

The class of RPS-style games

A competitive series of decisions with no long-term advantage accumulation and access at every decision to a set of moves that include trumps of opponents' moves
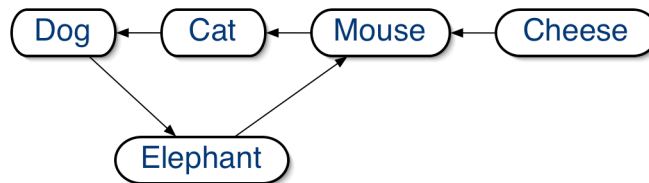
new york university
mrl

This is it! Pay attention because I'll be returning to this definition a lot.
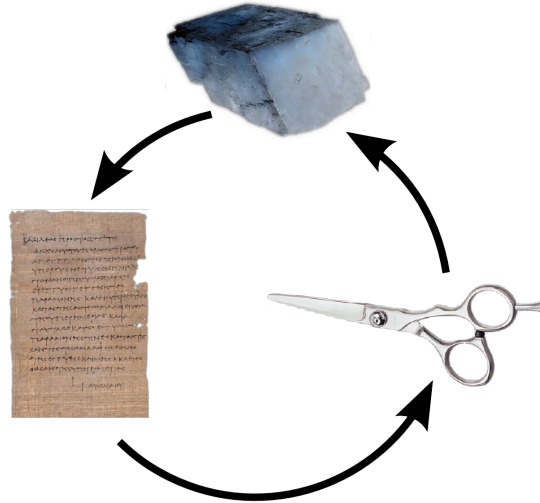
Nodes represent choices, and we draw an edge from a choice to its trumps.

Choices Graph

Dog ← Cat ← Mouse ← Cheese

Dog ← Cat ← Mouse ← Cheese

Dog → Elephant → Mouse

Elephant

2 more examples. The top graph has a choice with no trump, a sink. Always play dog!
The lower graph has no sinks.

Sinks have no trump
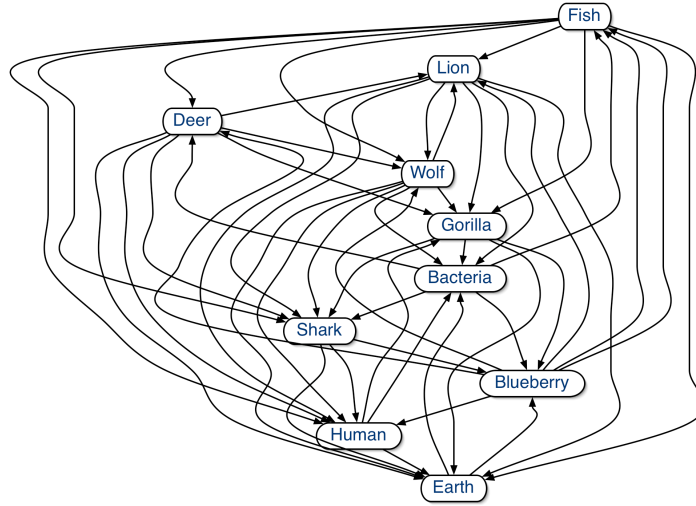
Every choice must have a trump.

Every node must have a trump -> no sinks. No sinks -> every node is either part of a cycle or on a path from a source to a cycle.

Poker

Credit: Kevin Labianco

Choice is already made, then the match is drawn out. Player choice limited to information release. No cyclic ordering of choices.

TODO: Something about playing a perfect game.

Long-term strategy games

Advantage accumulation
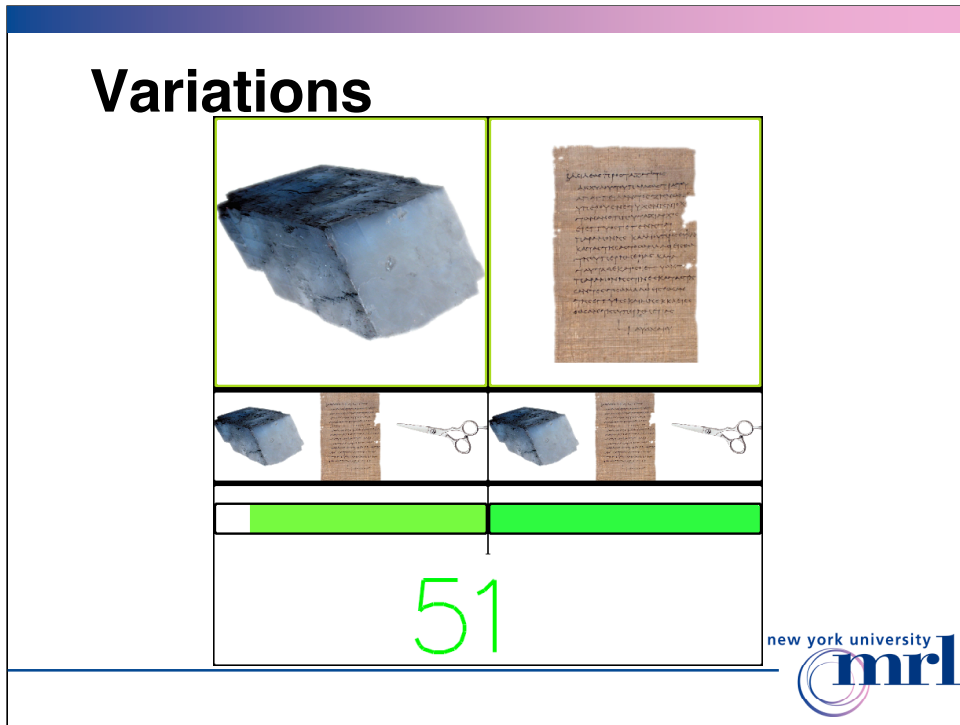
Credit: Simon Pais

new york university
mrl

Chess

turn-based or real-time strategy games

Advantage accumulation, plan moves far into the future.

Best 5/7 RPS adds state, but it's not advantage accumulation because each individual win is still just as easy to obtain.

Variations

51

new york university
mrl

Let's make variations and argue, for each variant, why it is still in the class of RPS-style games.

Describe rules precisely before showing each segment of video clip. Talk over the clip, too. "See how rock trumps paper"

VIDEO CLIPS!

[variant 1; async]

        - only change is removal of synchrony; not in the definition

        - since choices aren't discrete, we can't use the same game theoretic analysis.

        - score meter is similar to the best 5/7 count. State but no change to likelihood or score from winning a match.

[variant 2: retract times]

        - again only removed synchrony

        - given optimal reflexes, here optimal strategy is not to play at all. But players want to play, so they do.

[variant 3: variable throw timings]

        - same as 2. There are still trumps for every choice. (choices don't have to be balanced!)

[variant 4: strong/weak throws; gambits]

        - new time and score risk and reward choices

        - for each new throw, opponent still holds a trump

11

Street Fighter II

The Dojo / Kung Fu movies

Credit: myo_sim

new york university
mrl

Two opponents of similar strength bears strong resemblance to RPS, so it's not surprising the video game adaptation does, too. Have moves and trumps.

No longer a game --- the consequences are non-optional [Juul].

Button mashing

Randomly choosing throws

Credit: Advanced Media, Inc.

new york university
mrl

Game theory says, if moves and trumps were uniformly sampled (w.r.t. scoring), would average to a draw.

Popular strategy amongst unskilled players.

Sf2 is complex enough to be unbalanced, so uniform sampling doesn't guarantee a draw.

But if advanced player engages button masher in the subset of throws uniformly sampled, we should expect a draw.
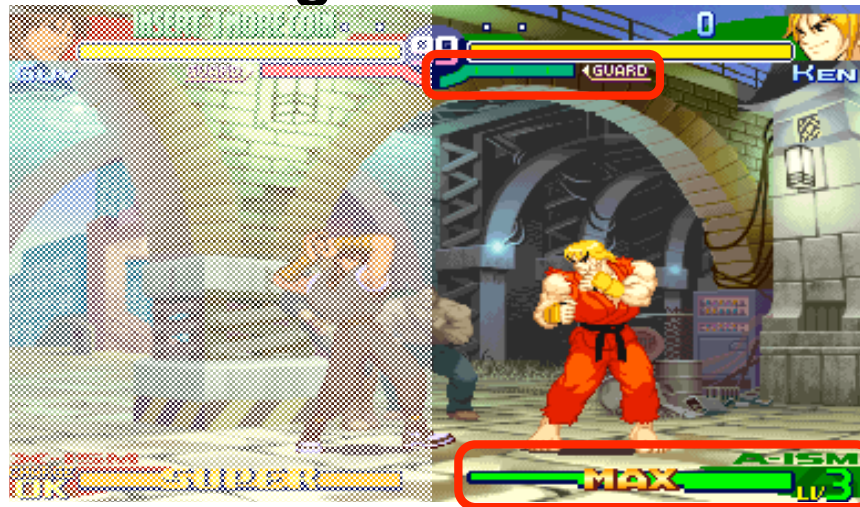
Guard meter, Alpha meter

Add short-term advantage accumulation -- designed to add balance and more strategy.

If long-term strategy elements are added (the more long-term strategy elements are added), the farther these games move from class of RPS-style games.

Future Work

Choice graph for Street Fighter II
## Constructive analysis on other game types

Directed graph of sf2 choices undrawn! Games with real-time decisions require a different game theoretic analysis than the one I presented.

By better understanding the class of an archetypical game, designers gain a better map of games and genres.

Allows for better informed design decisions (what games a design decision comes closer to), for studying prior work, and for foreseeing gameplay changes prior to prototyping.

Constructive analysis can be applied to any archetypical game and hypothesized member of its class. For example…

Space Invaders and Doom
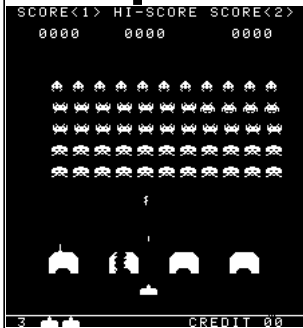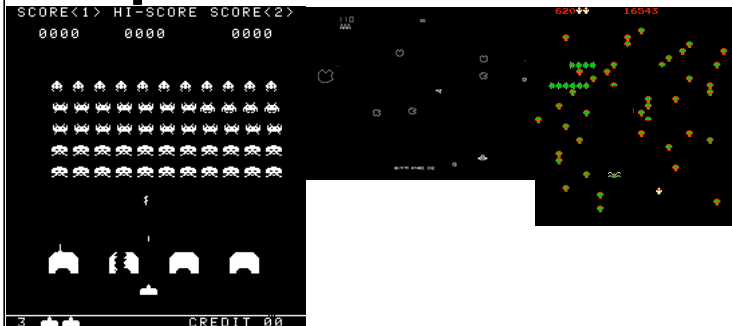
Space Invaders

Essence: Control a moving gun. Very little environment state (blocks), short-term strategy (skirmish to skirmish).

Asteroids/Centipede: Variations with more ship motion; we allow for this.

Crystal Quest/Robotron/Contra: More ship motion, More kinds of enemies, Portals to rooms, Power ups. Still no long-term strategy, little environmental state.

Doom: Only change is camera (first person view).

Space Invaders and Doom

Space Invaders
Asteroids
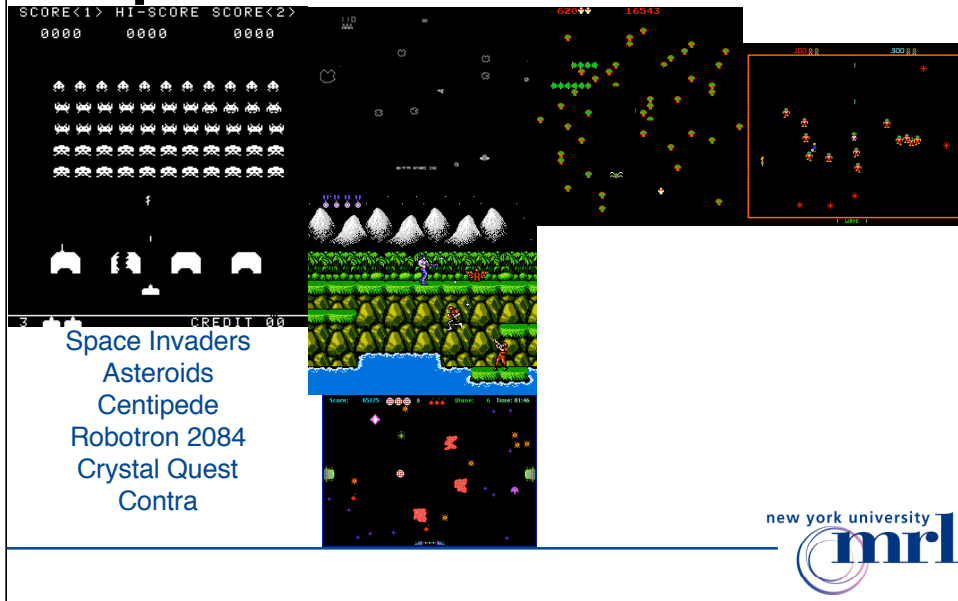Centipede

new york university
mrl

Essence: Control a moving gun. Very little environment state (blocks), short-term strategy (skirmish to skirmish).

Asteroids/Centipede: Variations with more ship motion; we allow for this.

Crystal Quest/Robotron/Contra: More ship motion, More kinds of enemies, Portals to rooms, Power ups. Still no long-term strategy, little environmental state.

Doom: Only change is camera (first person view).

Space Invaders and Doom

Space Invaders
Asteroids
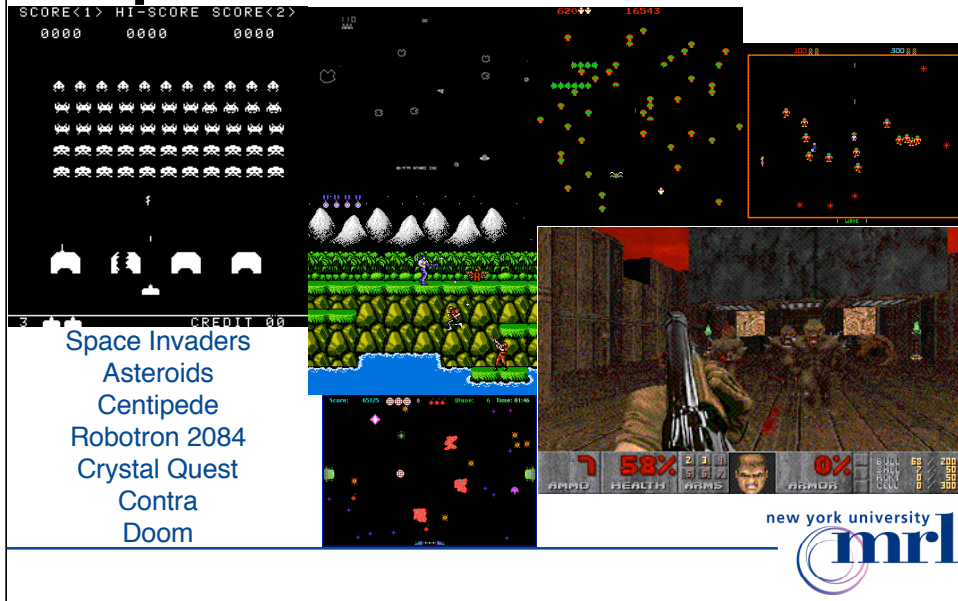Centipede
Robotron 2084
Crystal Quest
Contra

Essence: Control a moving gun. Very little environment state (blocks), short-term strategy (skirmish to skirmish).

Asteroids/Centipede: Variations with more ship motion; we allow for this.

Crystal Quest/Robotron/Contra: More ship motion, More kinds of enemies, Portals to rooms, Power ups. Still no long-term strategy, little environmental state.

Doom: Only change is camera (first person view).

Space Invaders and Doom

Space Invaders
Asteroids
Centipede
Robotron 2084
Crystal Quest
Contra
Doom

new york university
mrl

Essence: Control a moving gun. Very little environment state (blocks), short-term strategy (skirmish to skirmish).

Asteroids/Centipede: Variations with more ship motion; we allow for this.

Crystal Quest/Robotron/Contra: More ship motion, More kinds of enemies, Portals to rooms, Power ups. Still no long-term strategy, little environmental state.

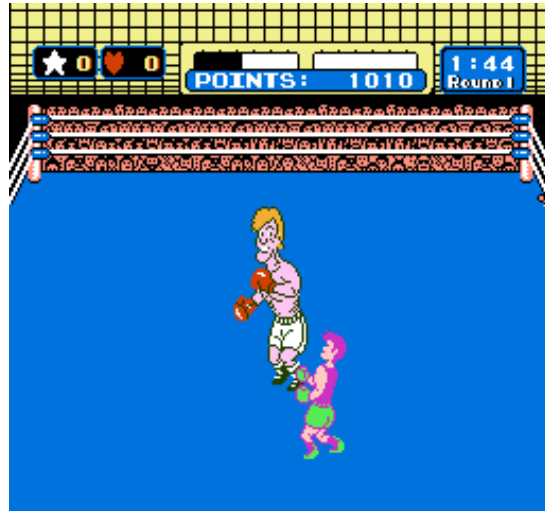Doom: Only change is camera (first person view).

Acknowledgements

Casey Muller, NYU colleagues, the anonymous reviewers, and Adobe

Contact: gingold@mrl.nyu.edu

new york university
mrl

Mike Tyson's Punch-Out

Is this really RPS-style?

Variations

565

171

10