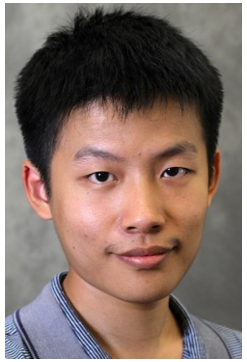
Moral Artificial Intelligence and the Societal Tradeoffs Problem

Vincent Conitzer, Duke University; joint work with:

Walter Sinnott-Armstrong

Jana Schaich Borg



Yuan Deng

Max Kramer

Rupert Freeman

Markus Brill

Yuqian Li

Some highly visible recent AI successes in games

Watson defeats Jeopardy champions (2011)

DeepMind achieves human-level performance on many Atari games (2015)

AlphaGo defeats Go champion (2016)

CMU’s Libratus defeats top human poker players (2017)

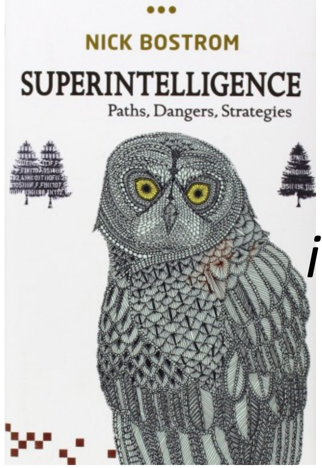
Typical picture in news articles

BusinessInsider reporting on the poker match…

Worries about AI - superintelligence

Nick Bostrom (philosopher at Oxford)

→ *writes*



NICK BOSTROM

SUPERINTELLIGENCE

Paths, Dangers, Strategies

→ *influences*

Elon Musk

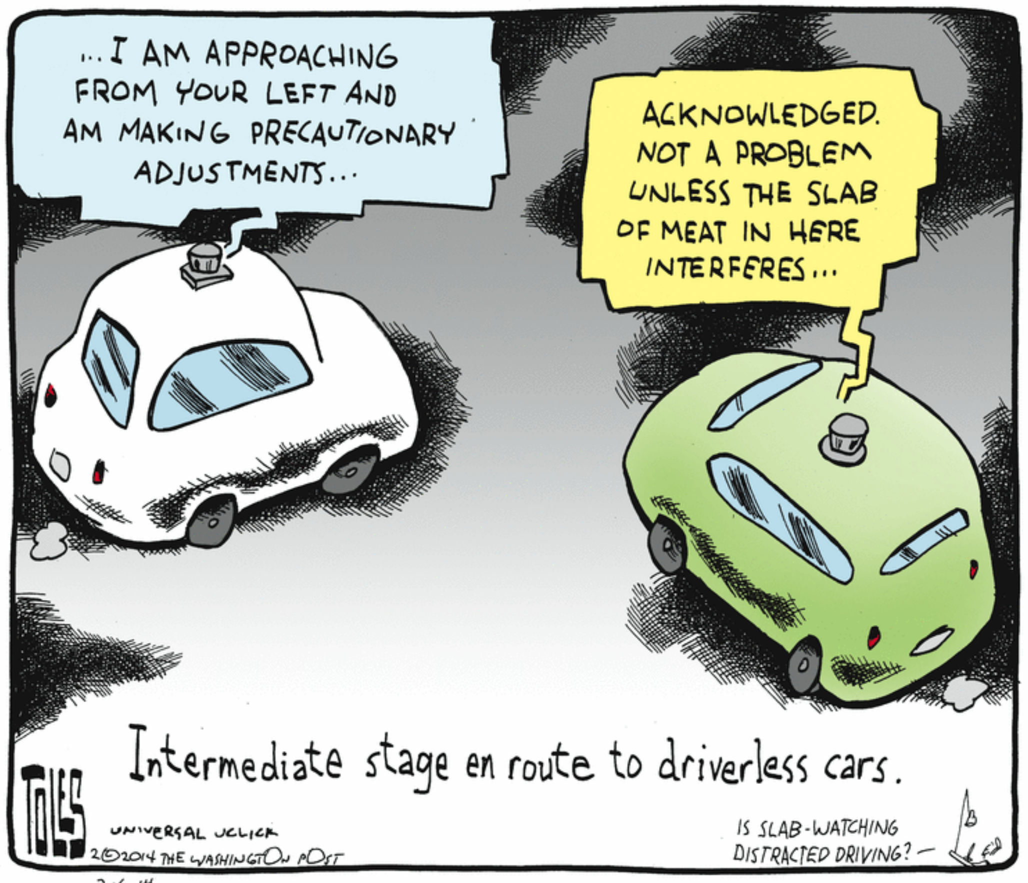
→ *donates to*

future of life INSTITUTE

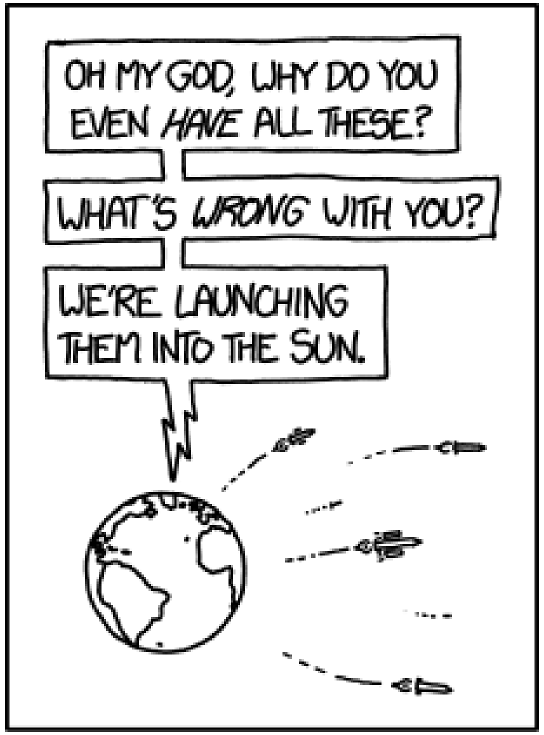
Worries about AI - near term

SCHEDULE A MEETING WITH DILBERT AND ALICE FOR NEXT TUESDAY AT TEN.
DONE
NEVER MIND. MY PHONE TOOK CARE OF IT.
AWKWARD.
Dilbert.com DilbertCartoonist@gmail.com
12-16-11 ©2011 Scott Adams, Inc./Dist. by Universal Uclick

technological unemployment


...I AM APPROACHING FROM YOUR LEFT AND AM MAKING PRECAUTIONARY ADJUSTMENTS...
ACKNOWLEDGED. NOT A PROBLEM UNLESS THE SLAB OF MEAT IN HERE INTERFERES...
Intermediate stage en route to driverless cars.
TOLES
UNIVERSAL UCLICK
©2014 THE WASHINGTON POST
IS SLAB-WATCHING DISTRACTED DRIVING?

autonomous vehicles – legal and other issues

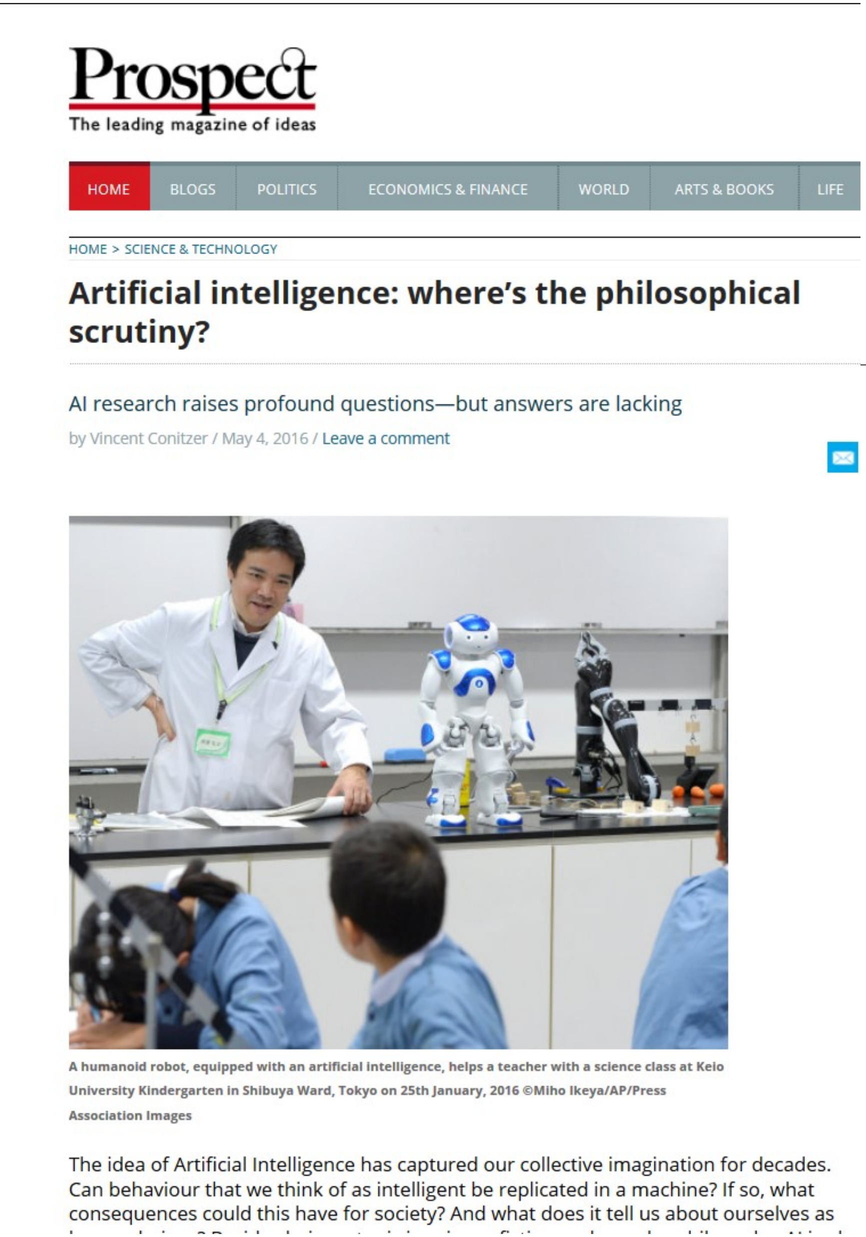

OH MY GOD, WHY DO YOU EVEN HAVE ALL THESE?
WHAT'S WRONG WITH YOU?
WE'RE LAUNCHING THEM INTO THE SUN.

THE MOMENT THE COMPUTERS CONTROLLING OUR NUCLEAR ARSENALS BECAME SENTIENT

autonomous weapon systems

...

Some popular articles



Prospect
The leading magazine of ideas

HOME > SCIENCE & TECHNOLOGY

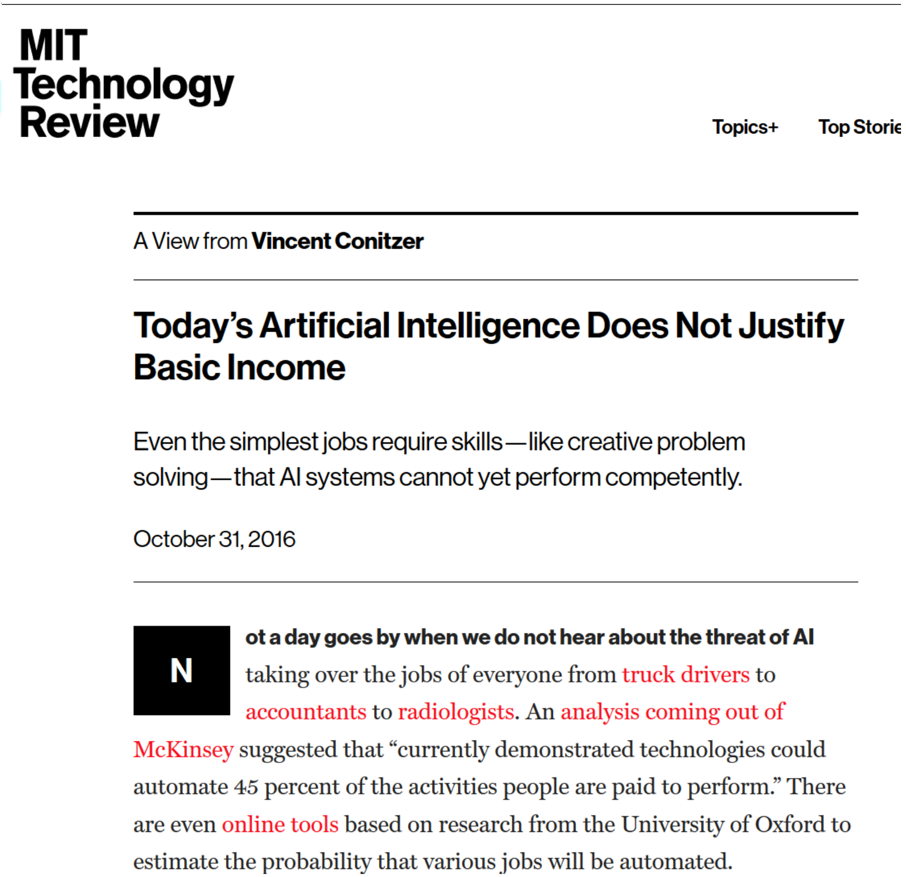
Artificial intelligence: where's the philosophical scrutiny?

AI research raises profound questions—but answers are lacking

by Vincent Conitzer / May 4, 2016 / Leave a comment

A humanoid robot, equipped with an artificial intelligence, helps a teacher with a science class at Keio University Kindergarten in Shibuya Ward, Tokyo on 25th January, 2016 ©Miho Ikeya/AP/Press Association Images

The idea of Artificial Intelligence has captured our collective imagination for decades. Can behaviour that we think of as intelligent be replicated in a machine? If so, what consequences could this have for society? And what does it tell us about ourselves as



MIT Technology Review

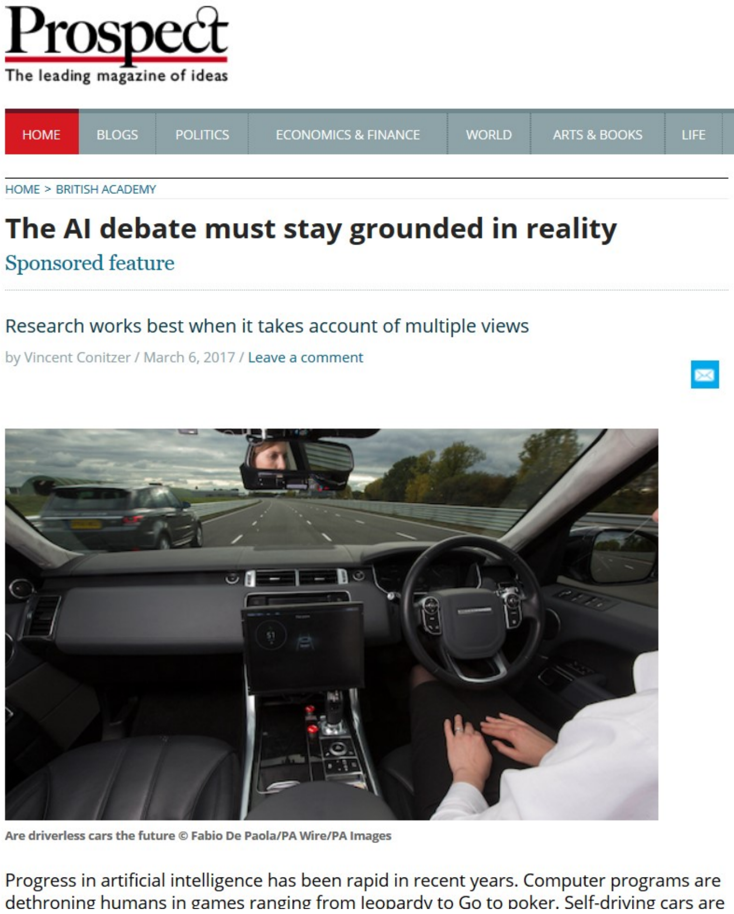
A View from **Vincent Conitzer**

Today's Artificial Intelligence Does Not Justify Basic Income

Even the simplest jobs require skills—like creative problem solving—that AI systems cannot yet perform competently.

October 31, 2016

Not a day goes by when we do not hear about the threat of AI taking over the jobs of everyone from truck drivers to accountants to radiologists. An analysis coming out of McKinsey suggested that "currently demonstrated technologies could automate 45 percent of the activities people are paid to perform." There are even online tools based on research from the University of Oxford to estimate the probability that various jobs will be automated.



Prospect
The leading magazine of ideas

HOME > BRITISH ACADEMY

The AI debate must stay grounded in reality

Sponsored feature

Research works best when it takes account of multiple views

by Vincent Conitzer / March 6, 2017 / Leave a comment

Are driverless cars the future © Fabio De Paola/PA Wire/PA Images

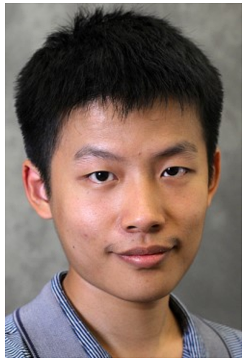
Progress in artificial intelligence has been rapid in recent years. Computer programs are dethroning humans in games ranging from Jeopardy to Go to poker. Self-driving cars are

Moral Decision Making Frameworks for Artificial Intelligence

[Proc. AAAI'17]

Walter Sinnott-Armstrong

Jana Schaich Borg



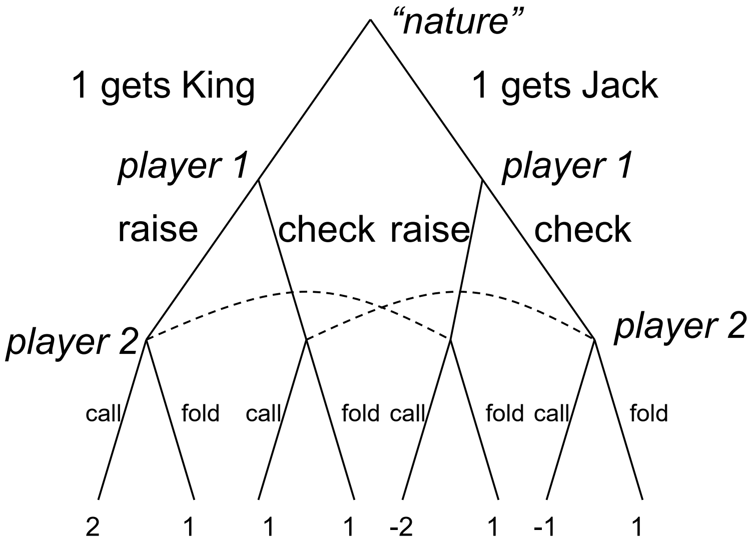
Yuan Deng

Max Kramer

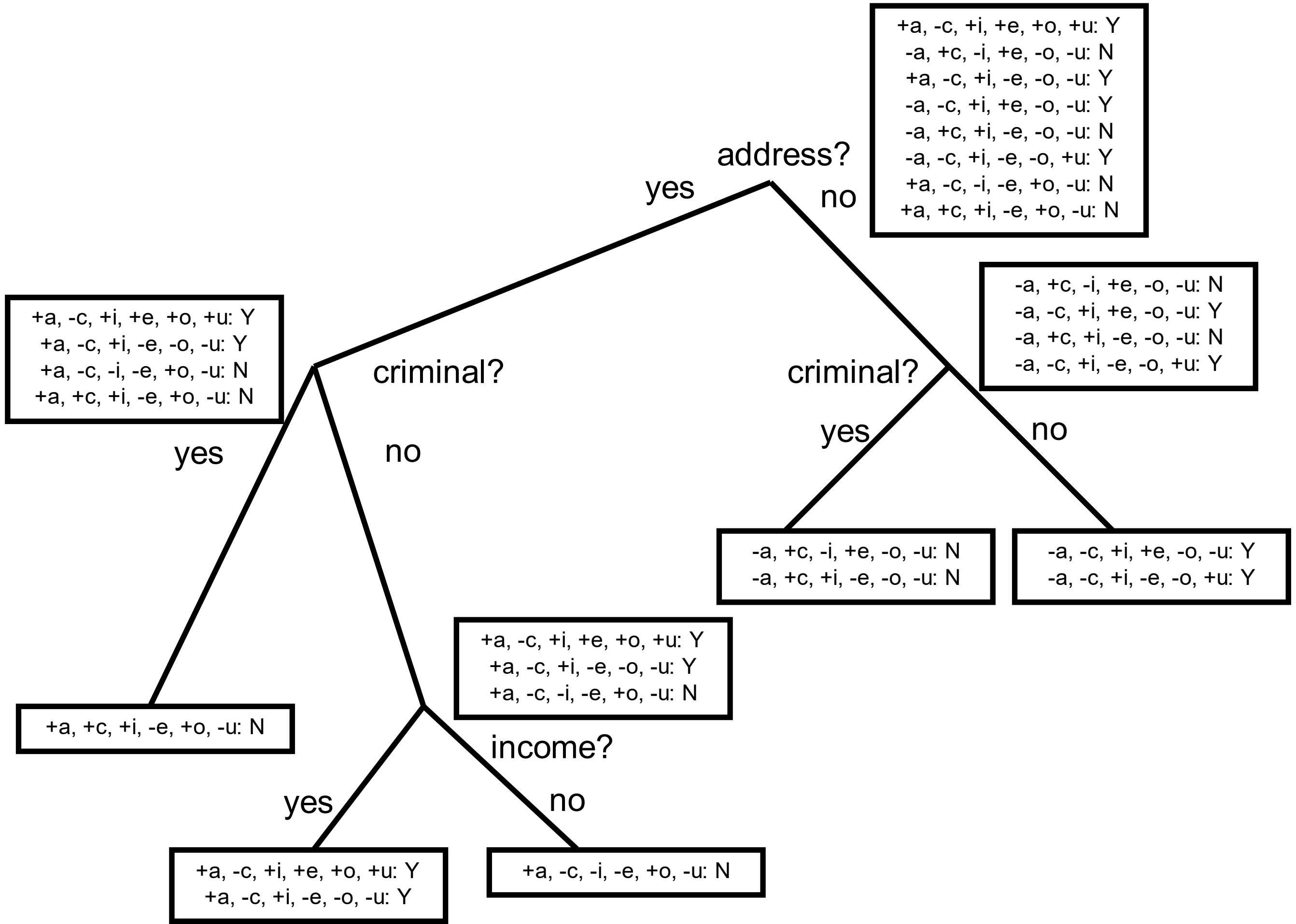
Two main approaches

Cf. top-down vs. bottom-up distinction [Wallach and Allen 2008]

Extend **game theory** to directly incorporate moral reasoning



Generate data sets of human judgments, apply **machine learning**



+a, -c, +i, +e, +o, +u: Y
-a, +c, -i, +e, -o, -u: N
+a, -c, +i, -e, -o, -u: Y
-a, -c, +i, +e, -o, -u: Y
-a, +c, +i, -e, -o, -u: N
-a, -c, +i, -e, -o, +u: Y
+a, -c, -i, -e, +o, -u: N
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+a, -c, +i, -e, -o, -u: Y

+a, -c, -i, -e, +o, -u: N

-a, +c, -i, +e, -o, -u: N
-a, -c, +i, +e, -o, -u: Y
-a, +c, +i, -e, -o, -u: N
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-a, +c, -i, +e, -o, -u: N
-a, +c, +i, -e, -o, -u: N

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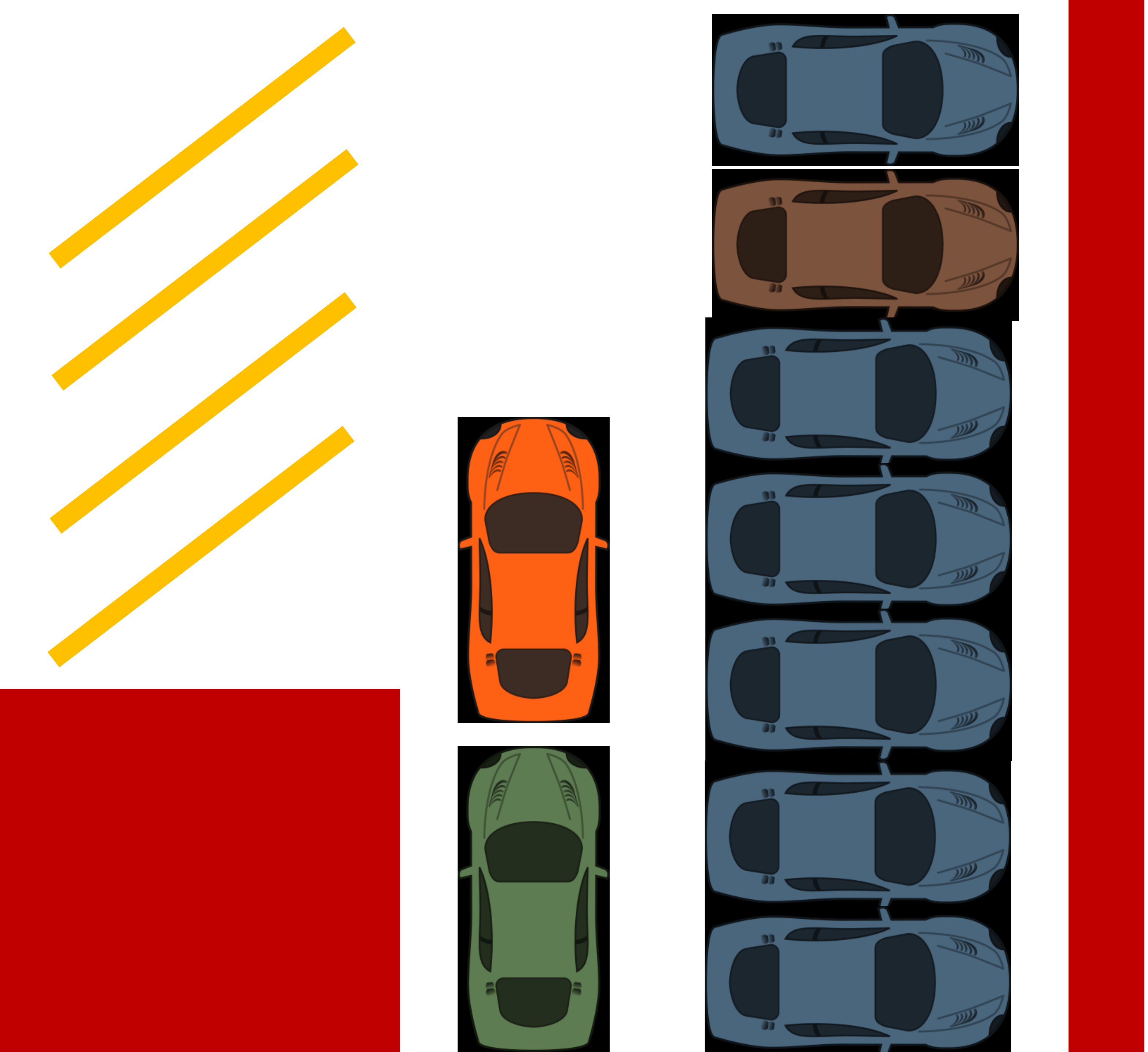
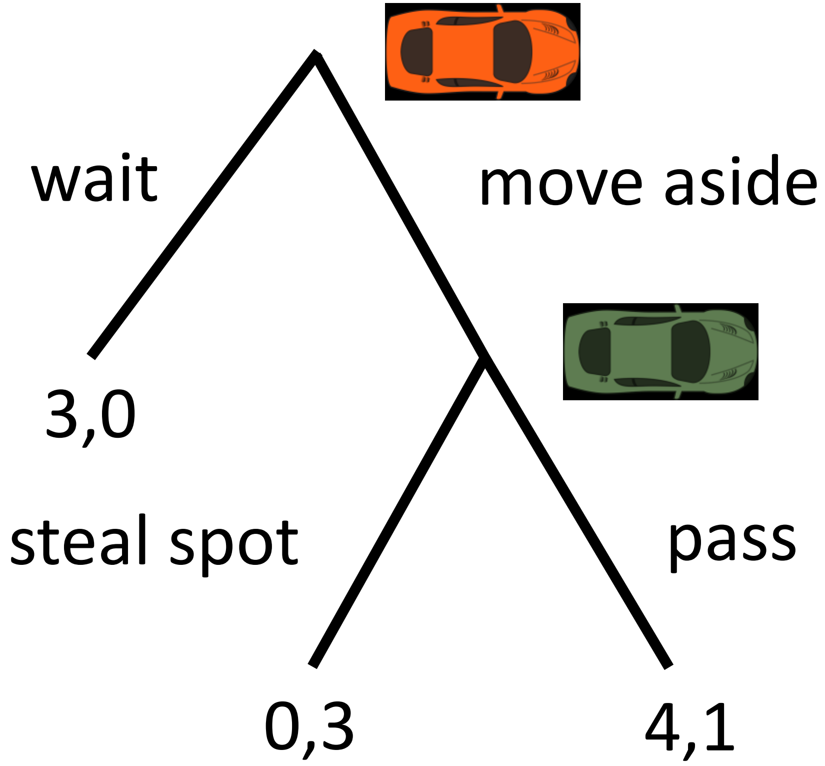


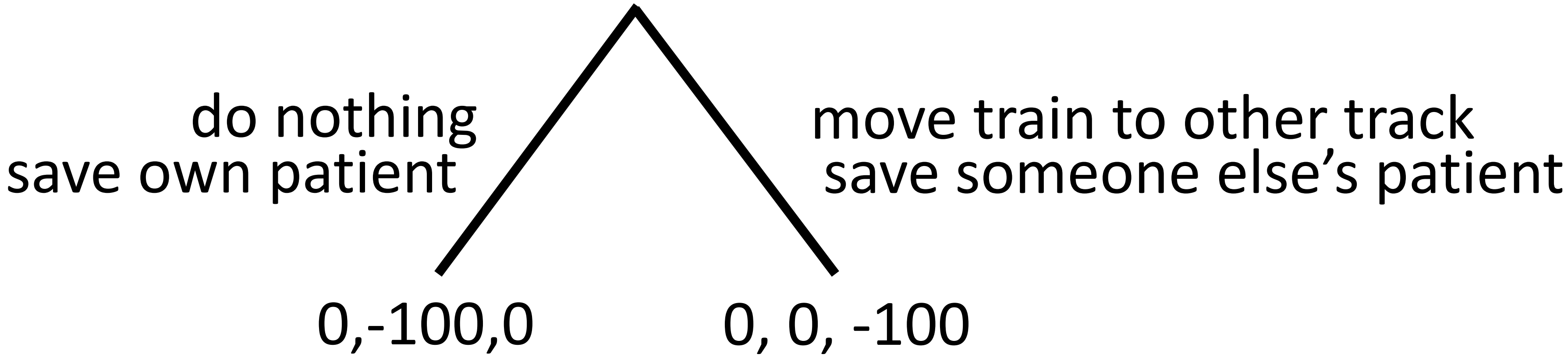
THE PARKING GAME

(cf. the trust game [Berg et al. 1995])



Letchford, C., Jain [2008] define a solution concept capturing this

Extending representations?



do nothing
save own patient

move train to other track
save someone else's patient

0,-100,0

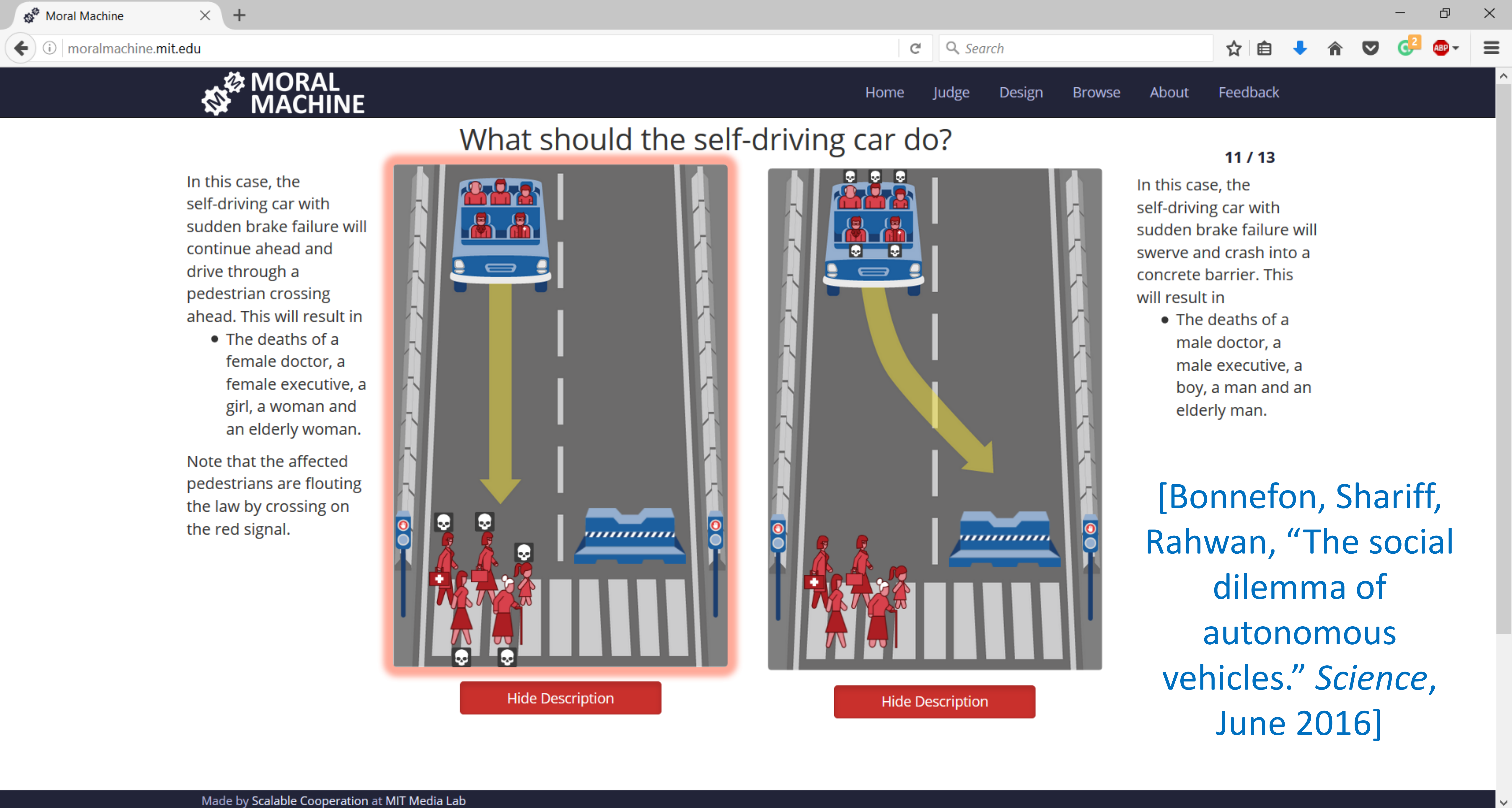
0, 0, -100

- More generally: how to capture *framing*? (Should we?)
- Roles? Relationships?
- …

Scenarios

- You see a woman throwing a stapler at her colleague who is snoring during her talk. How morally wrong is the action depicted in this scenario?
  - Not at all wrong (1)
  - Slightly wrong (2)
  - Somewhat wrong (3)
  - Very wrong (4)
  - Extremely wrong (5)

[Clifford, Iyengar, Cabeza, and Sinnott-Armstrong, "Moral foundations vignettes: A standardized stimulus database of scenarios based on moral foundations theory." *Behavior Research Methods*, 2015.]



What should the self-driving car do?

11 / 13

In this case, the self-driving car with sudden brake failure will continue ahead and drive through a pedestrian crossing ahead. This will result in

- The deaths of a female doctor, a female executive, a girl, a woman and an elderly woman.

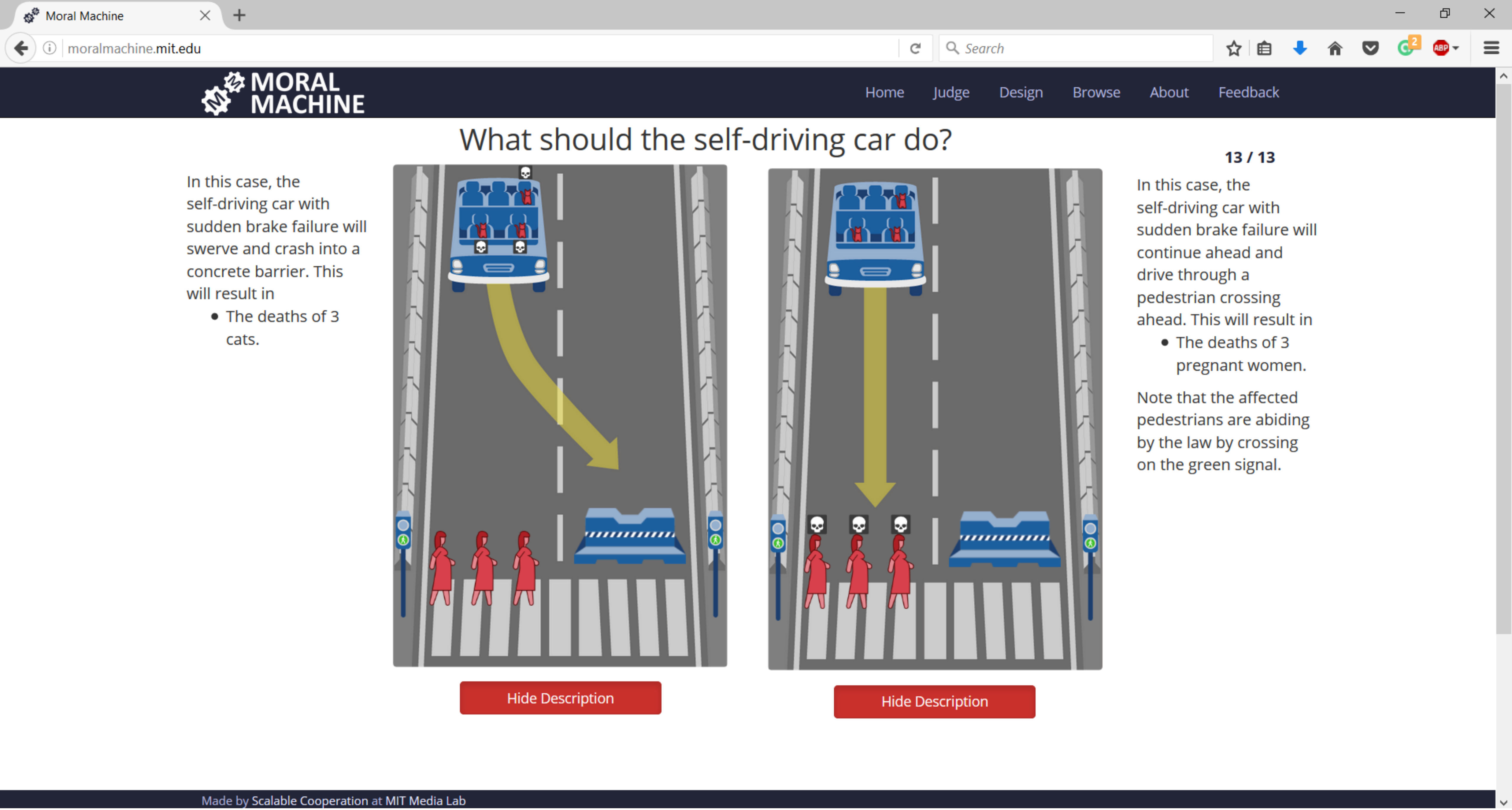
Note that the affected pedestrians are flouting the law by crossing on the red signal.

In this case, the self-driving car with sudden brake failure will swerve and crash into a concrete barrier. This will result in

- The deaths of a male doctor, a male executive, a boy, a man and an elderly man.

Made by Scalable Cooperation at MIT Media Lab

[Bonnefon, Shariff, Rahwan, “The social dilemma of autonomous vehicles.” *Science*, June 2016]



What should the self-driving car do?

13 / 13

In this case, the self-driving car with sudden brake failure will swerve and crash into a concrete barrier. This will result in

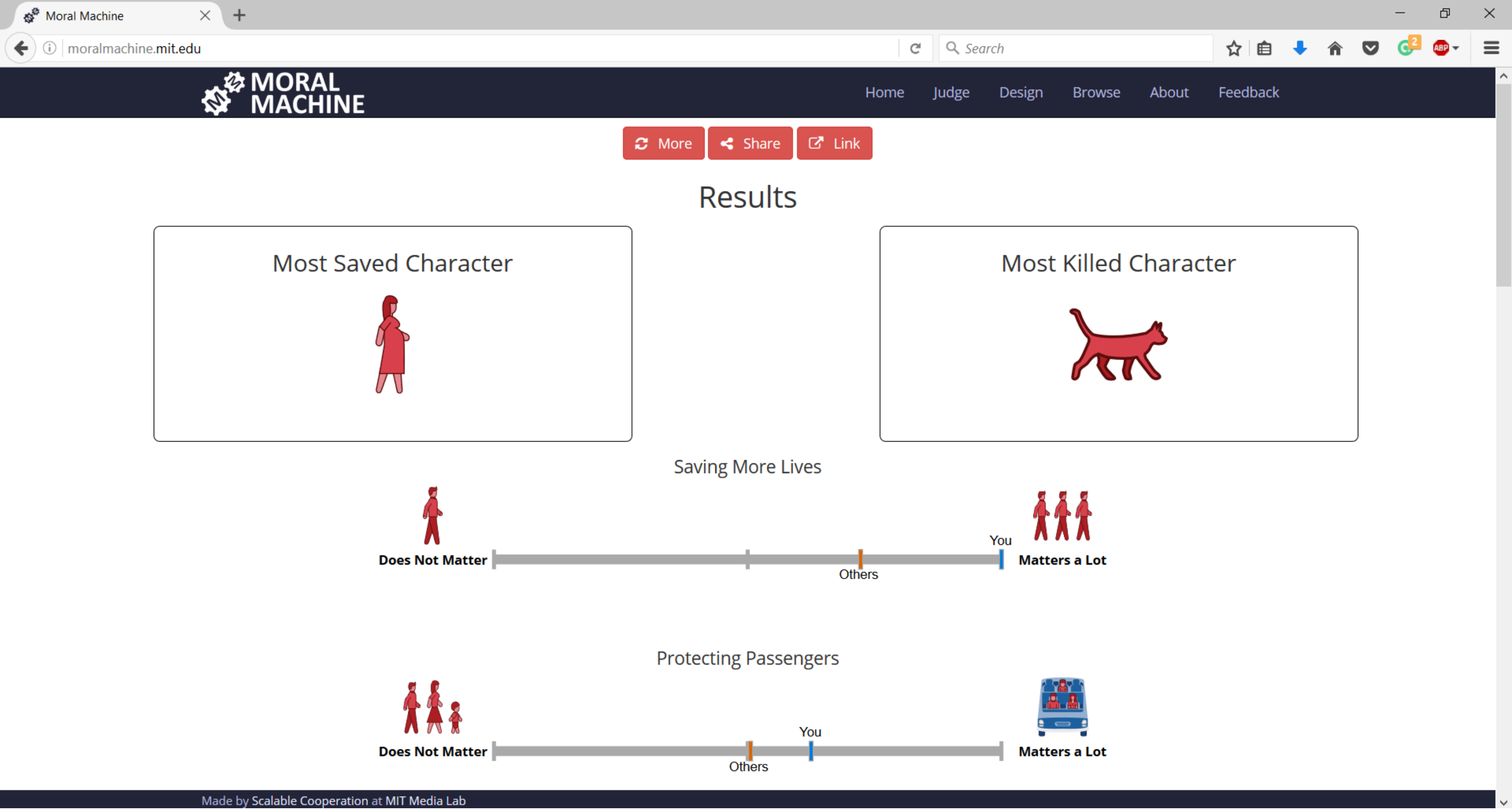
- The deaths of 3 cats.

In this case, the self-driving car with sudden brake failure will continue ahead and drive through a pedestrian crossing ahead. This will result in

- The deaths of 3 pregnant women.

Note that the affected pedestrians are abiding by the law by crossing on the green signal.

Made by Scalable Cooperation at MIT Media Lab



Results

Most Saved Character

Most Killed Character

Saving More Lives

Does Not Matter — Matters a Lot

You

Others

Protecting Passengers

Does Not Matter — Matters a Lot

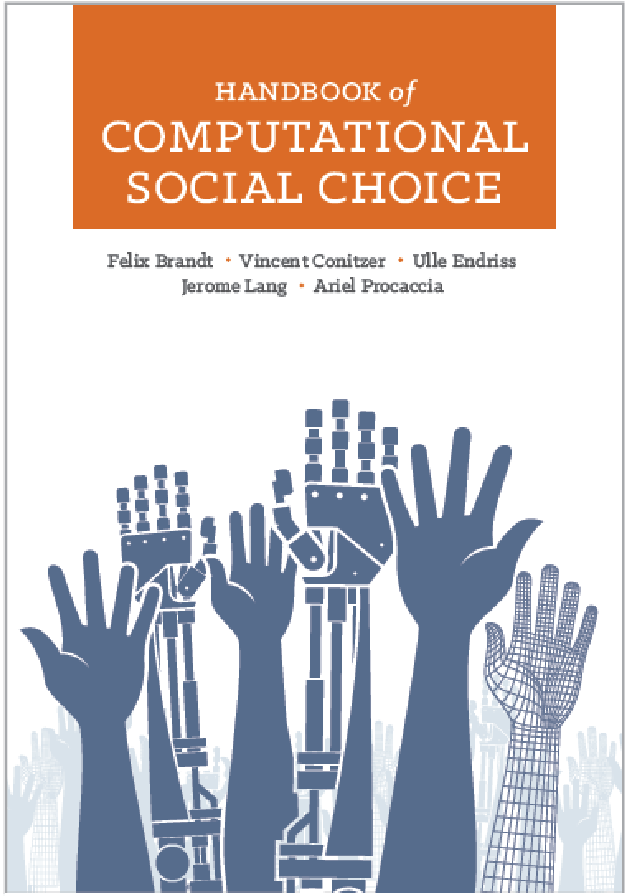
You

Others

Made by Scalable Cooperation at MIT Media Lab

Concerns with the ML approach

- What if we predict people will disagree?
  - Social-choice theoretic questions [see also Rossi 2016]
- This will *at best* result in current human-level moral decision making [raised by, e.g., Chaudhuri and Vardi 2014]
  - … though might perform better than any *individual* person because individual's errors are voted out
- How to generalize appropriately? Representation?


HANDBOOK of
COMPUTATIONAL
SOCIAL CHOICE
Felix Brandt · Vincent Conitzer · Ulle Endriss
Jerome Lang · Ariel Procaccia

Crowdsourcing Societal Tradeoffs

(Proc. AAMAS'15; AAAI'16; ongoing work.)

with Rupert Freeman, Markus Brill, Yuqian Li

The basic version of our problem

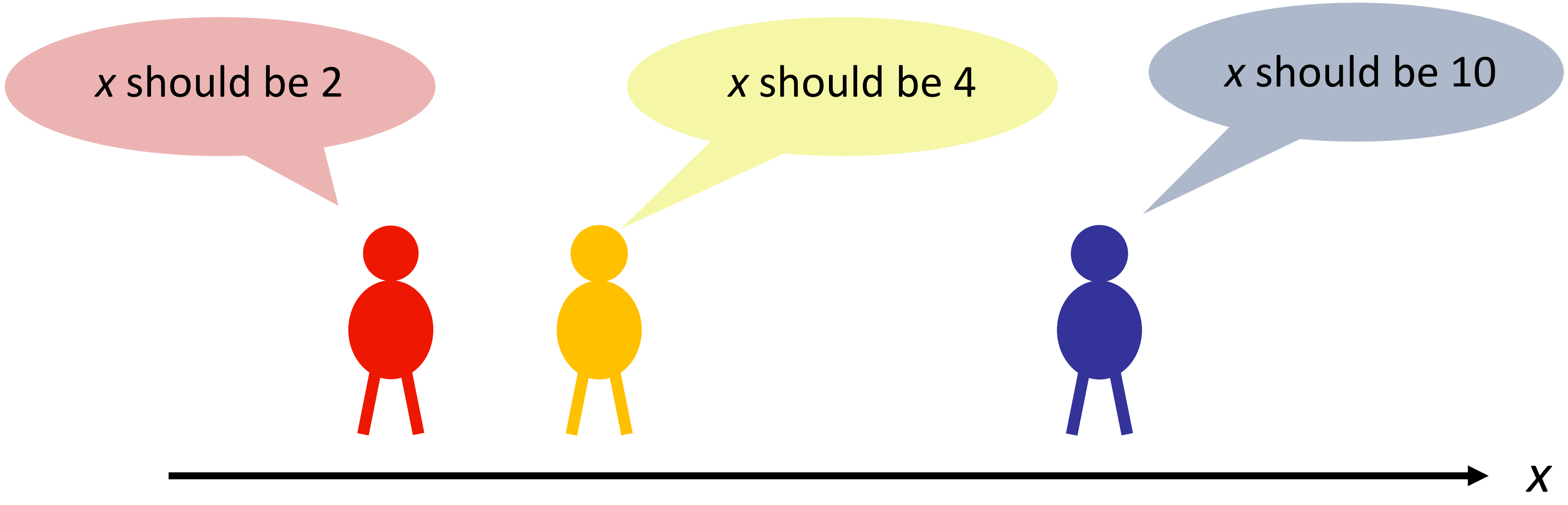
producing 1 bag
of landfill trash

is as bad as

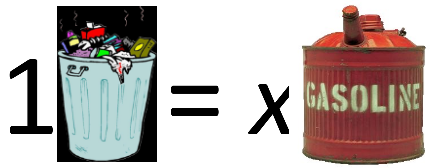
using ***x*** gallons
of gasoline

*How to determine **x**?*

One Approach: Let’s Vote!

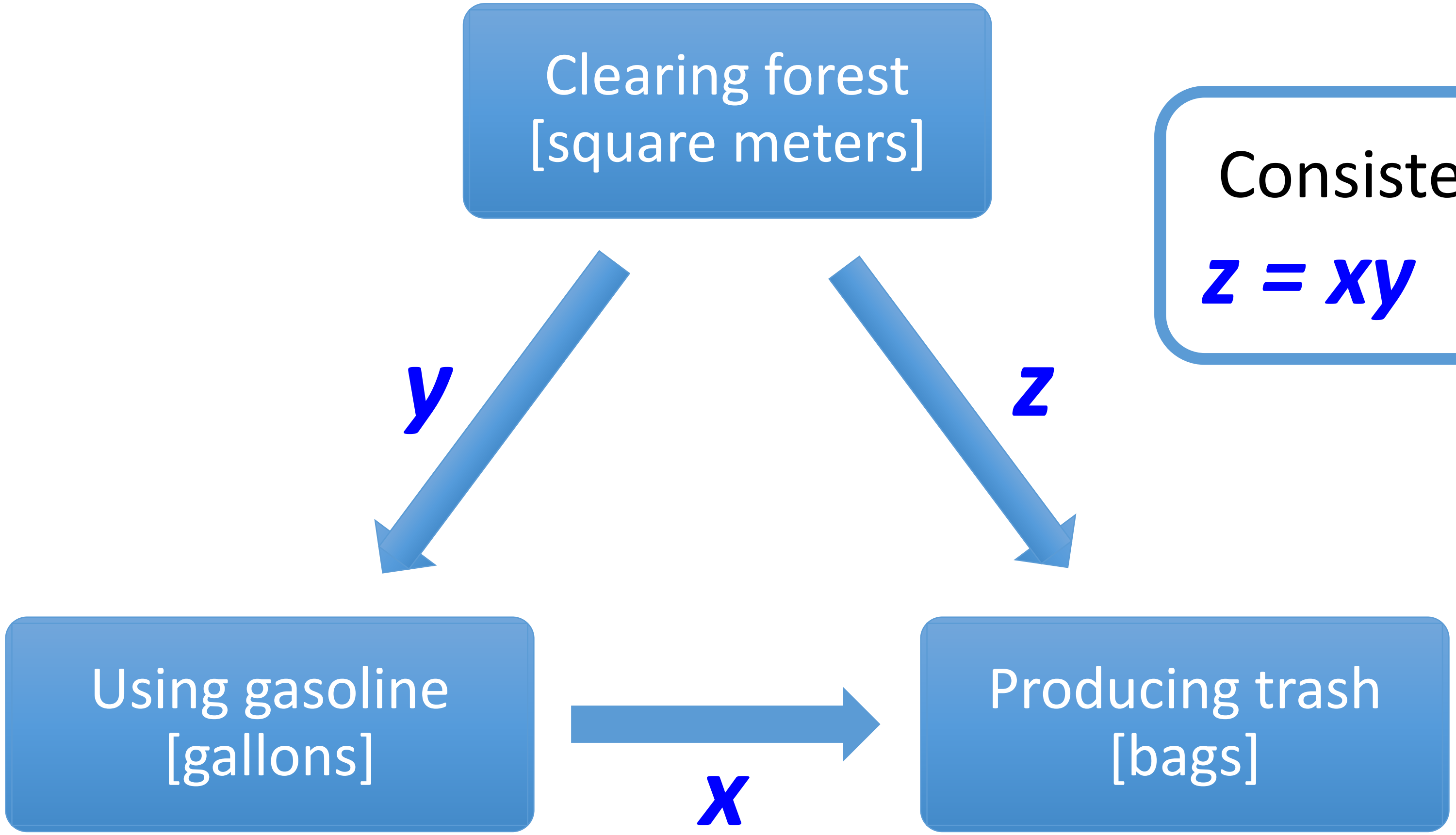


- What should the outcome be…?
  - Average? Median?



- Assuming that preferences are single-peaked, selecting the median is strategy-proof and has other desirable social choice-theoretic properties

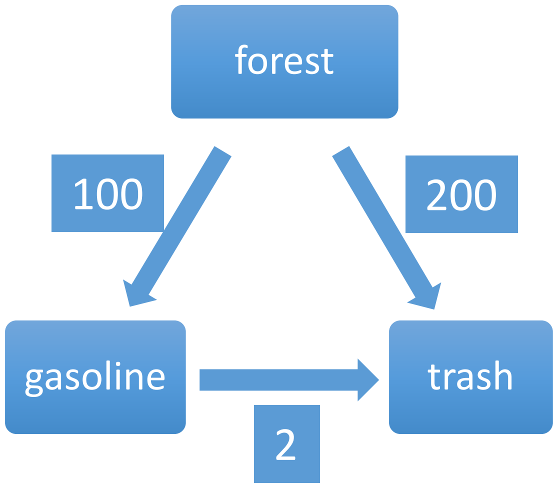
Consistency of tradeoffs

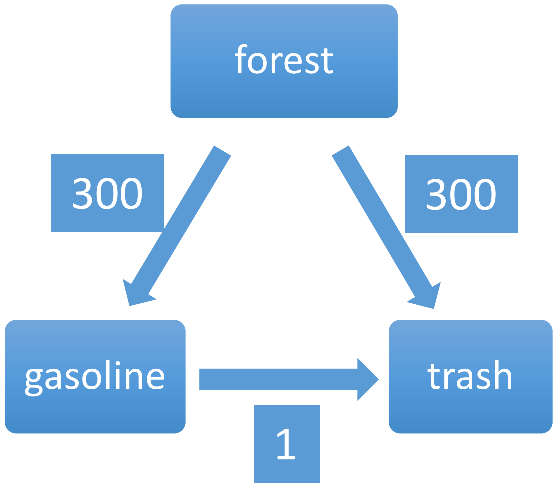


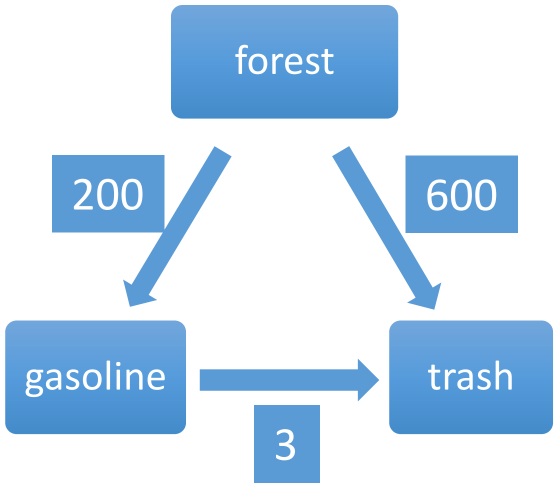
Consistency:

$z = xy$

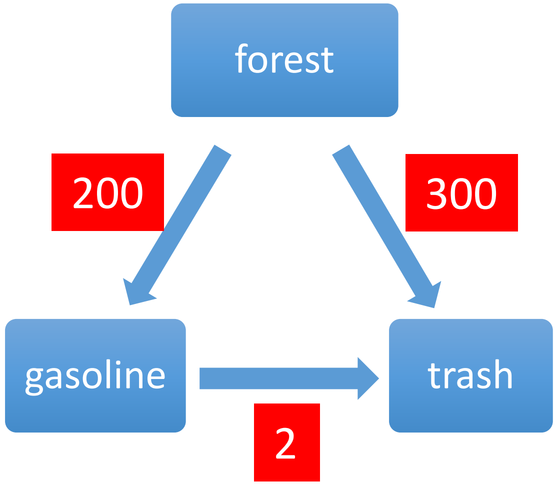
A paradox





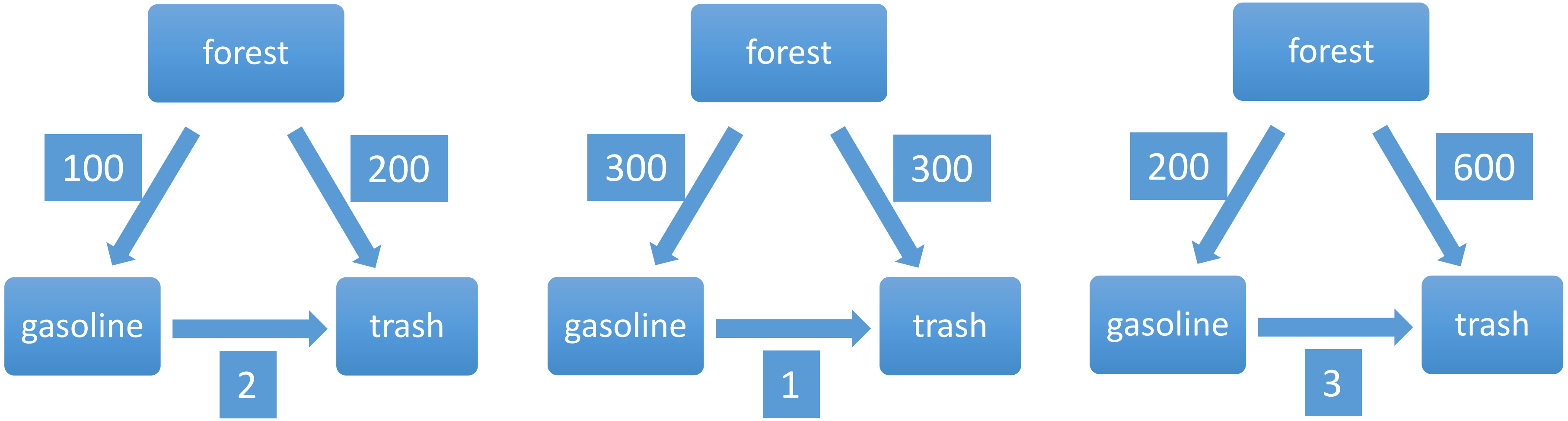


Just taking medians pairwise results in inconsistency



A first attempt at a rule satisfying consistency

- Let $t_{a,b,i}$ be voter i's tradeoff between a and b
- Aggregate tradeoff graph t has score $\Sigma_i \Sigma_{a,b} \mid t_{a,b} - t_{a,b,i} \mid$

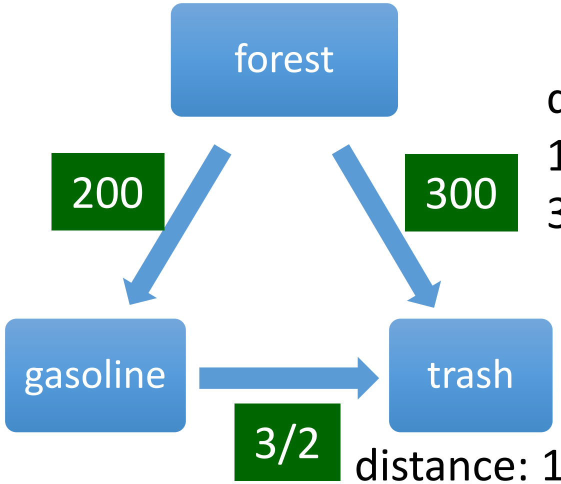


forest
100
200
gasoline
trash
2

forest
300
300
gasoline
trash
1

forest
200
600
gasoline
trash
3

distance:
100 to v_1
100 to v_2



forest
200
300
gasoline
trash
3/2

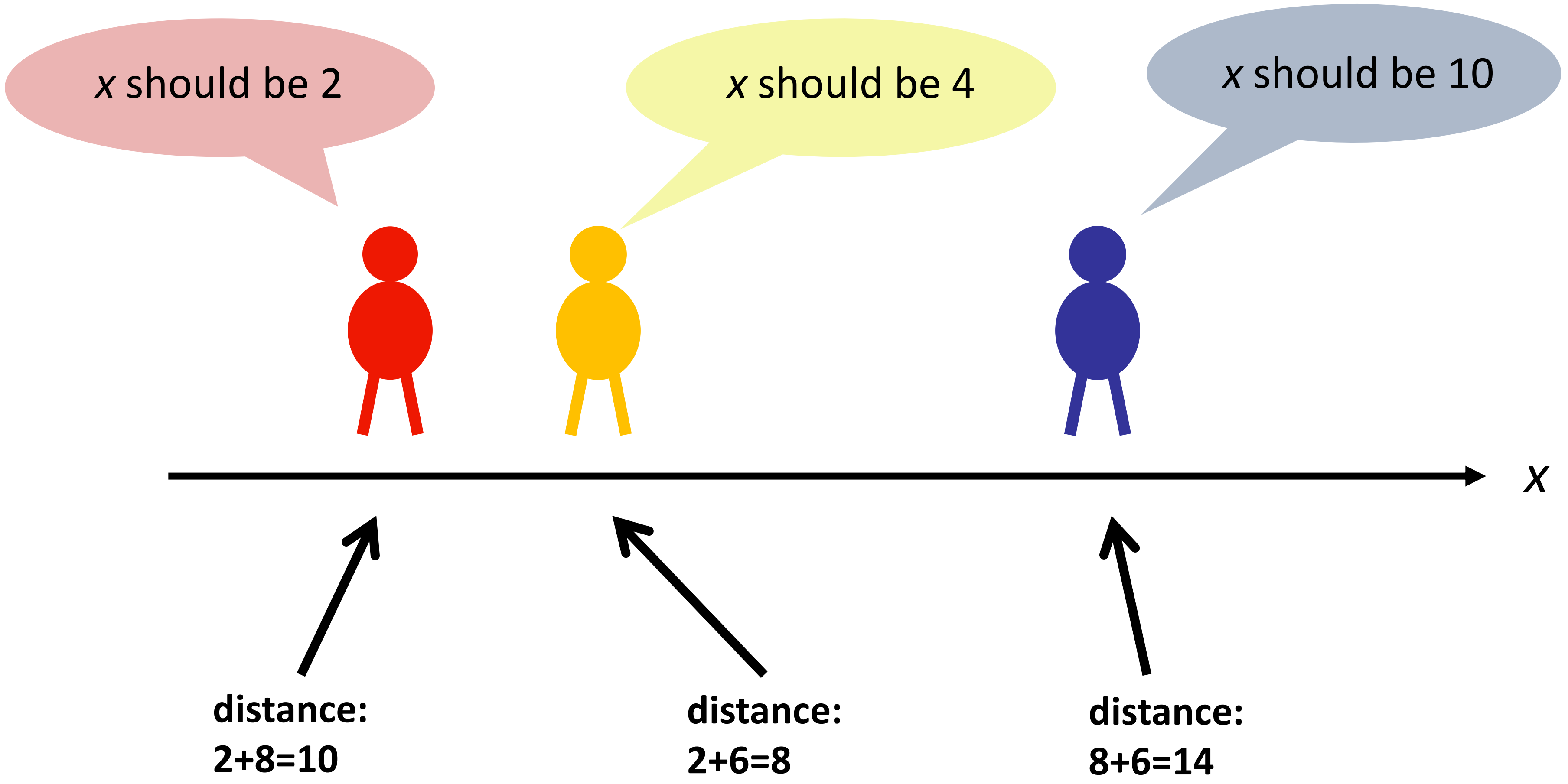
distance:
100 to v_1
300 to v_3

distance: 1/2 to v_1,1/2 to v_2, 3/2 to v_3

total distance: 602.5 (minimum)

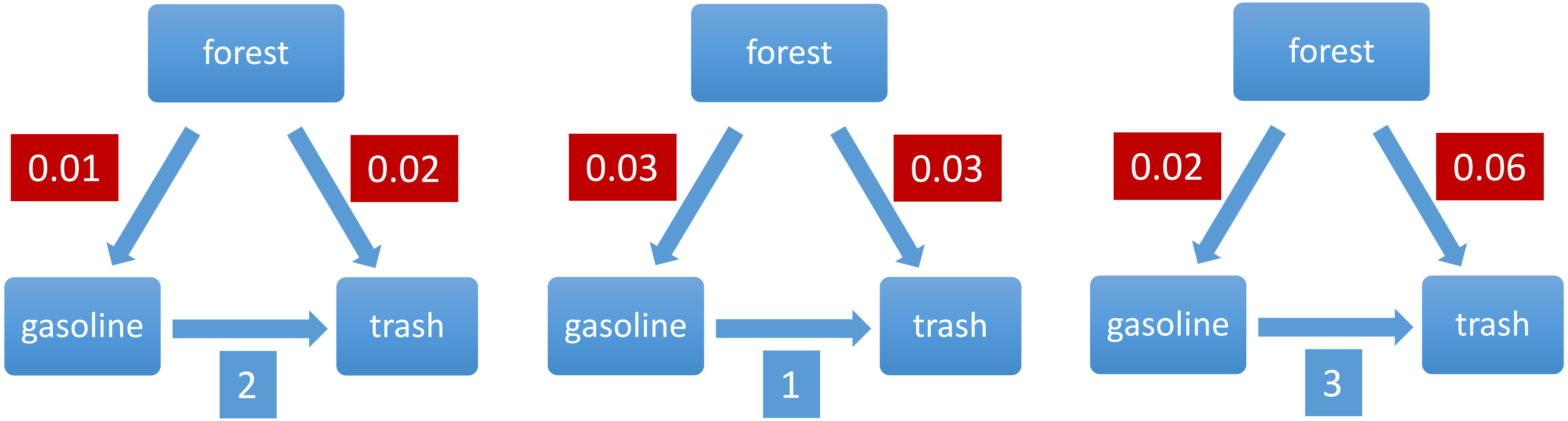
A nice property

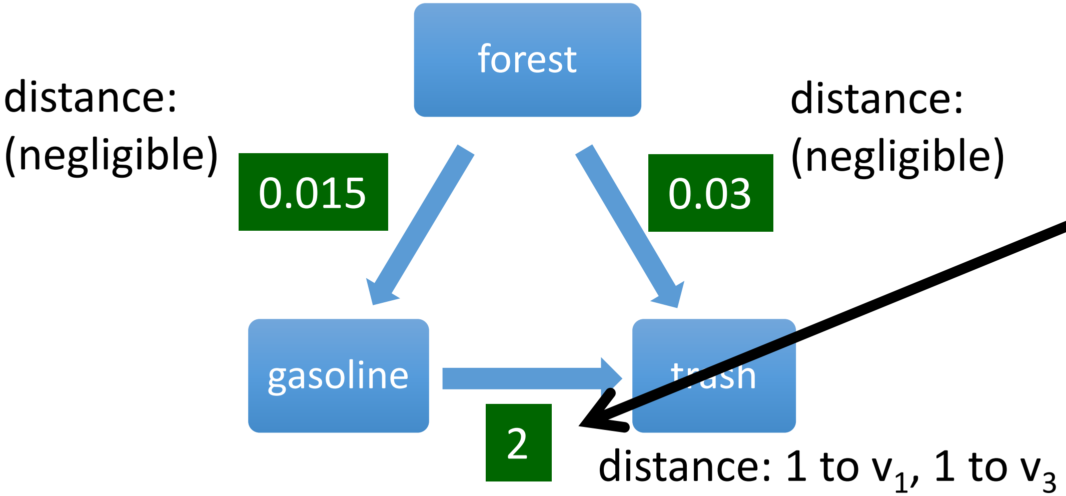
- This rule agrees with the median when there are only two activities!



Not all is rosy, part 1

- What if we change units? Say forest from m^2 to cm^2 (divide by 10,000)

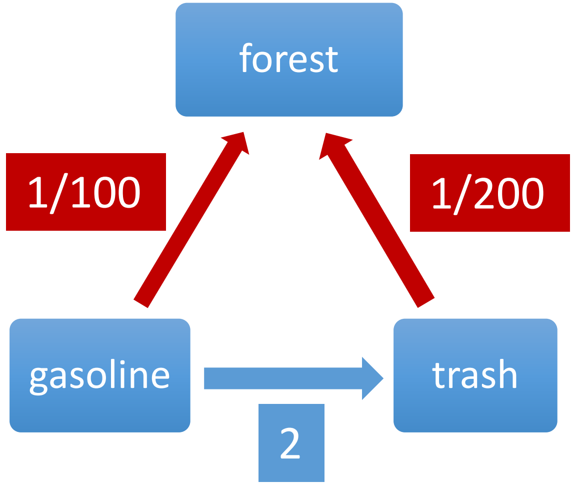


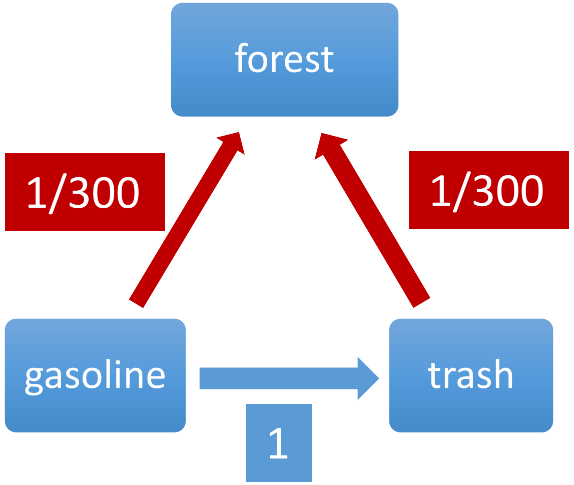


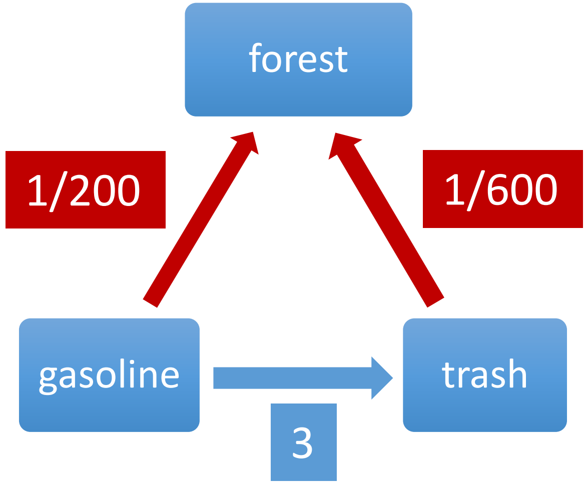
different from before!
fails independence of other activities' units

Not all is rosy, part 2

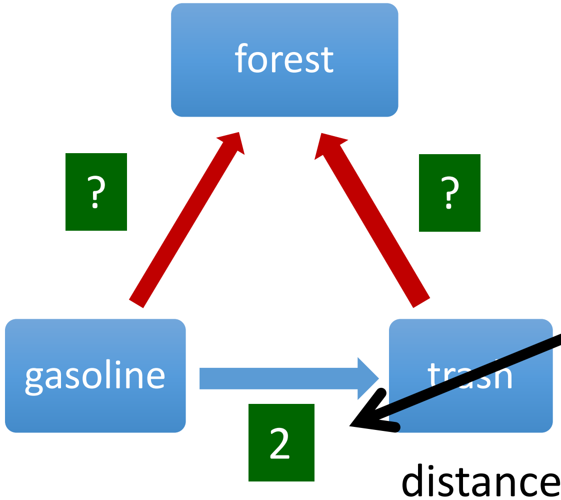
- Back to original units, but let’s change some edges’ direction







distance:
(negligible)



distance:
(negligible)

different from before!
fails independence of other edges’ directions

distance: 1 to v_1, 1 to v_3

Summarizing

- Let $t_{a,b,i}$ be voter i's tradeoff between a and b
- Aggregate tradeoff graph t has score

  $\Sigma_i \Sigma_{a,b} \mid t_{a,b} - t_{a,b,i} \mid$
- Upsides:
  - Coincides with median for 2 activities
- Downsides:
  - Dependence on choice of units:

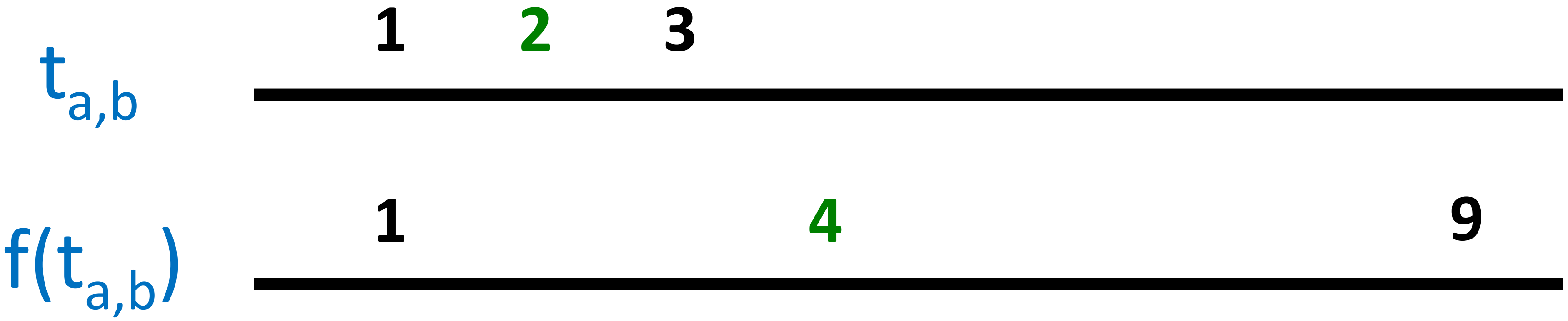
    $\mid t_{a,b} - t_{a,b,i} \mid \neq \mid 2t_{a,b} - 2t_{a,b,i} \mid$
  - Dependence on direction of edges:

    $\mid t_{a,b} - t_{a,b,i} \mid \neq \mid 1/t_{a,b} - 1/t_{a,b,i} \mid$
  - We don't have a general algorithm

A generalization

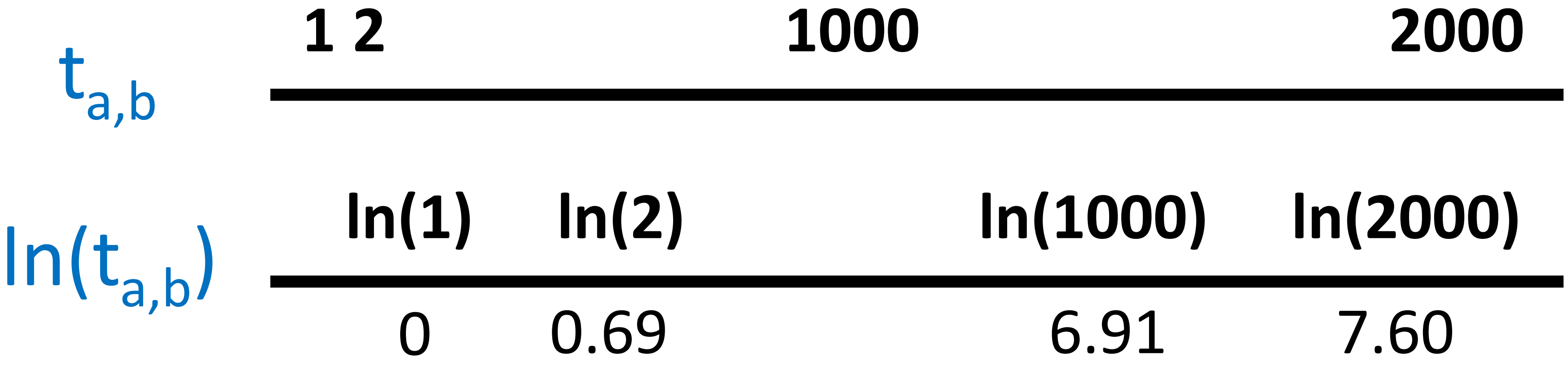
- Let $t_{a,b,i}$ be voter i's tradeoff between a and b
- Let f be a monotone increasing function – say, $f(x) = x^2$
- Aggregate tradeoff graph t has score

  $\Sigma_i \, \Sigma_{a,b} \mid f(t_{a,b}) - f(t_{a,b,i}) \mid$
- Still coincides with median for 2 activities!
- **Theorem:** These are the **only** rules satisfying this property, agent separability, and edge separability



So what’s a good f?

- Intuition: Is the difference between tradeoffs of 1 and 2 the same as between 1000 and 1001, or as between 1000 and 2000?
- So how about $f(x)=\log(x)$?
  - (Say, base e – remember $\log_a(x)=\log_b(x)/\log_b(a)$)



$t_{a,b}$

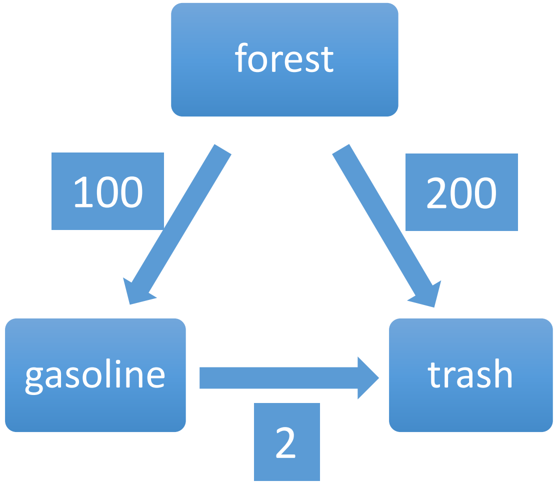
1 2 **1000** **2000**

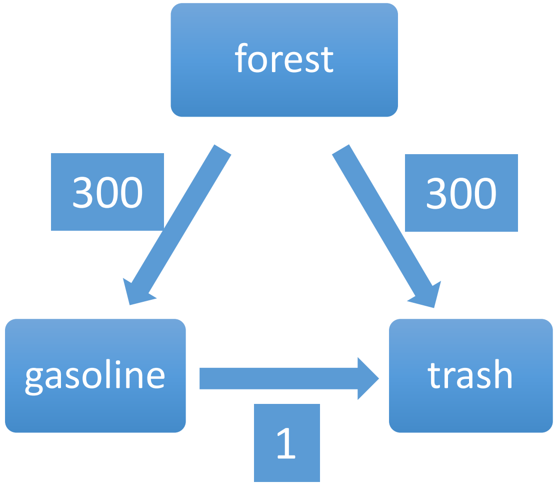
$\ln(t_{a,b})$

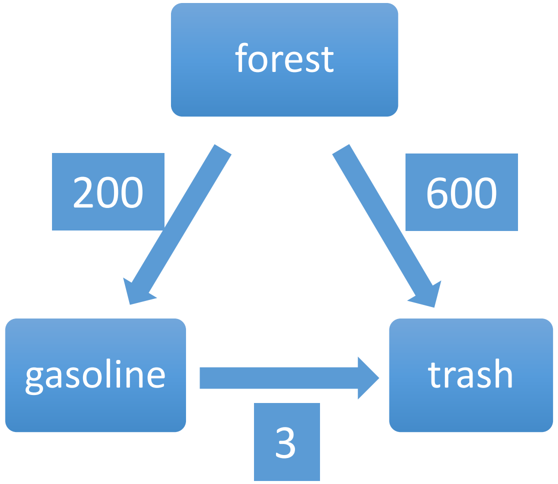
ln(1) **ln(2)** **ln(1000)** **ln(2000)**

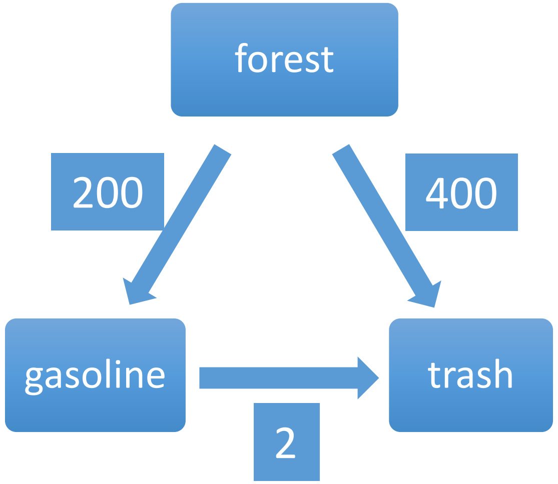
0 0.69 6.91 7.60

On our example









Properties

- Independence of units

  $| \log(1) - \log(2) | = | \log(1/2) | =$

  $| \log(1000/2000) | = | \log(1000) - \log(2000) |$

  More generally:

  $| \log(ax) - \log(ay) | = | \log(x) - \log(y) |$

- Independence of edge direction

  $| \log(x) - \log(y) | = | \log(1/y) - \log(1/x) | =$

  $| \log(1/x) - \log(1/y) |$

- **Theorem.** The logarithmic distance based rule is unique in satisfying independence of units.*

  * Depending on the exact definition of independence of units, may need another minor condition about the function locally having bounded derivative.

Consistency constraint becomes additive

$xy = z$

is equivalent to

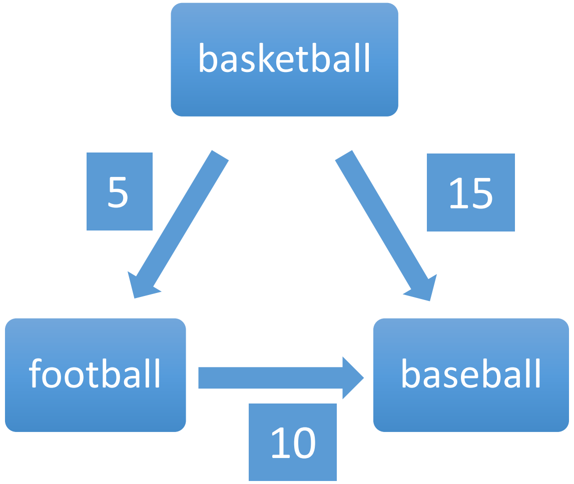
$\log(xy) = \log(z)$

is equivalent to

$\log(x) + \log(y) = \log(z)$

An additive variant

- “I think basketball is 5 units more fun than football, which in turn is 10 units more fun than baseball”


basketball

5

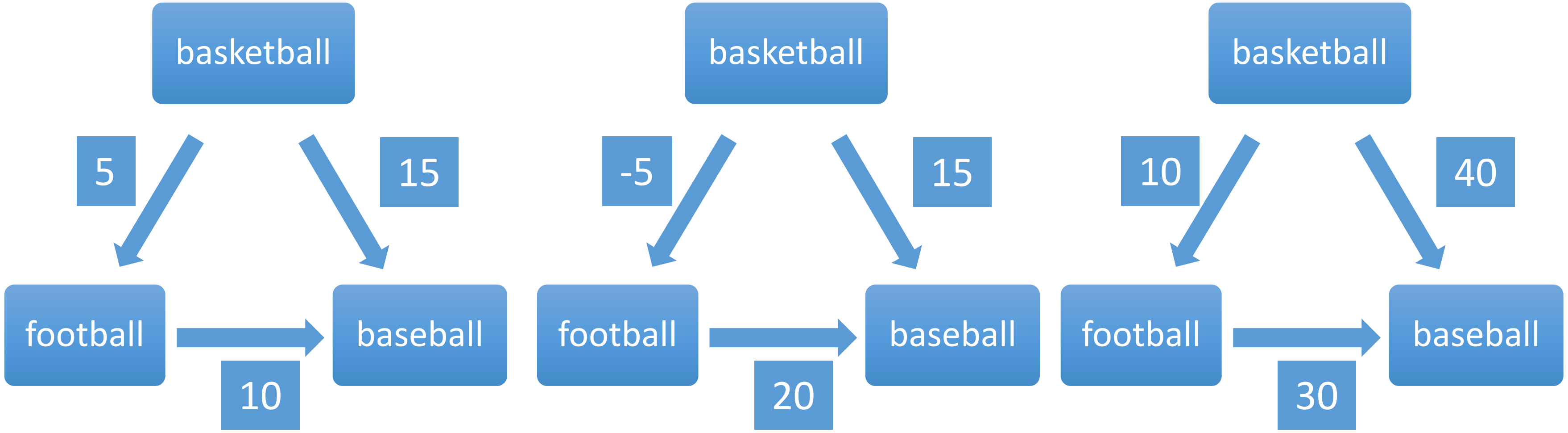
15

football

baseball

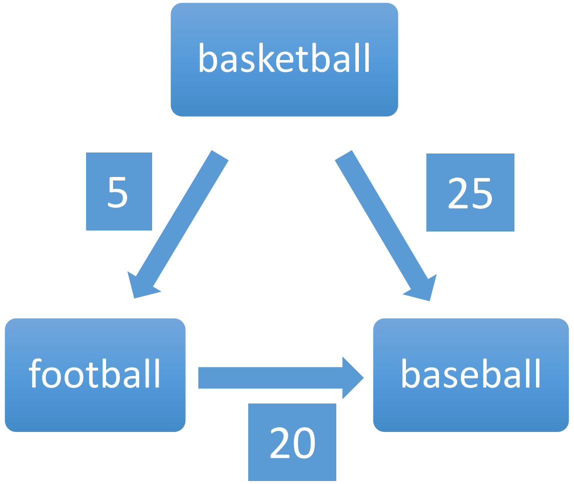
10

Aggregation in the additive variant



Natural objective:

minimize $\Sigma_i \Sigma_{a,b} d_{a,b,i}$ where $d_{a,b,i} = | t_{a,b} - t_{a,b,i} |$ is the distance between the aggregate difference $t_{a,b}$ and the subjective difference $t_{a,b,i}$



objective value 70 (optimal)

A linear program for the additive variant

q_a: aggregate assessment of quality of activity a (we're really interested in $q_a - q_b = t_{a,b}$)

$d_{a,b,i}$: how far is i's preferred difference $t_{a,b,i}$ from aggregate $q_a - q_b$, i.e., $d_{a,b,i} = |q_a - q_b - t_{a,b,i}|$

minimize $\Sigma_i \Sigma_{a,b} d_{a,b,i}$

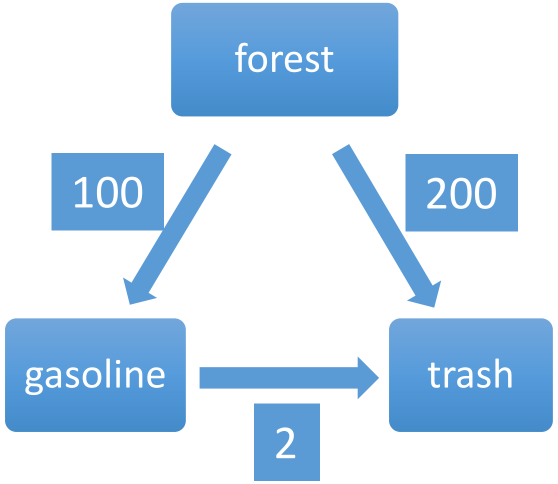
subject to

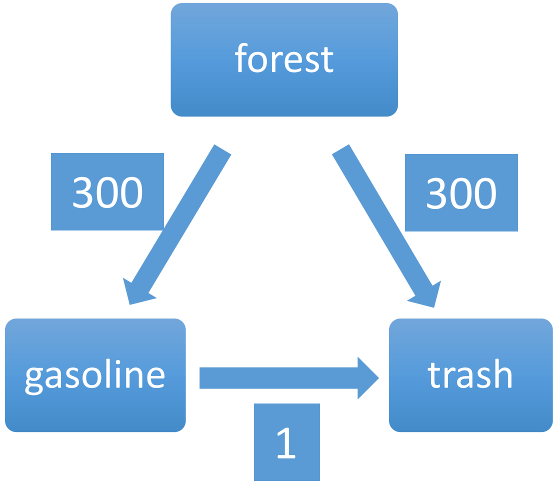
for all a,b,i: $d_{a,b,i} \geq q_a - q_b - t_{a,b,i}$

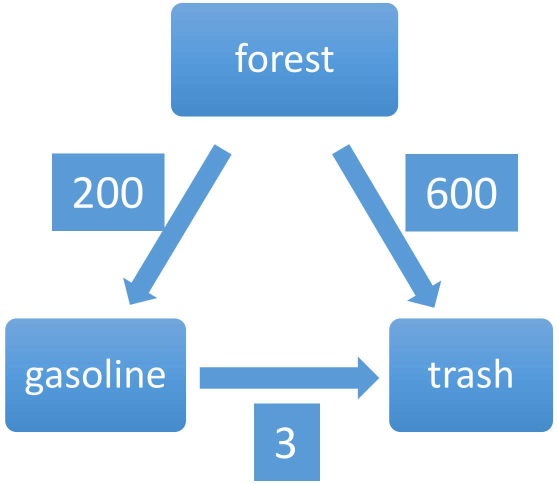
for all a,b,i: $d_{a,b,i} \geq t_{a,b,i} - q_a + q_b$

(Can arbitrarily set one of the q variables to 0)

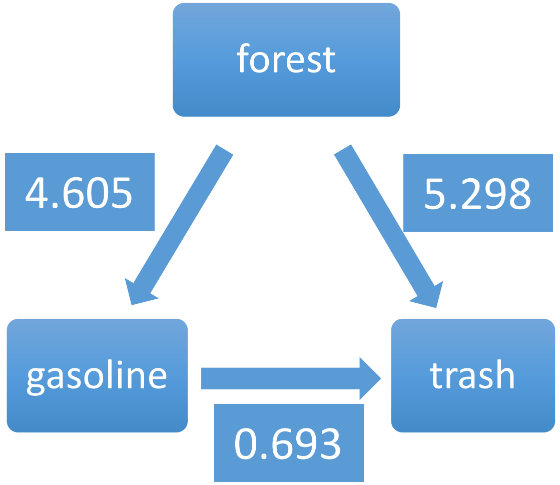
Applying this to the logarithmic rule in the multiplicative variant

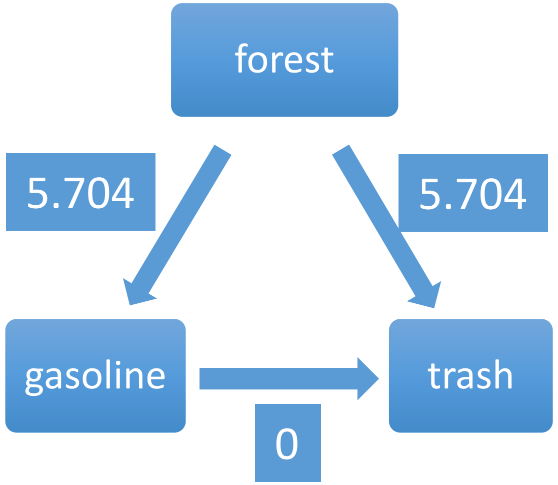


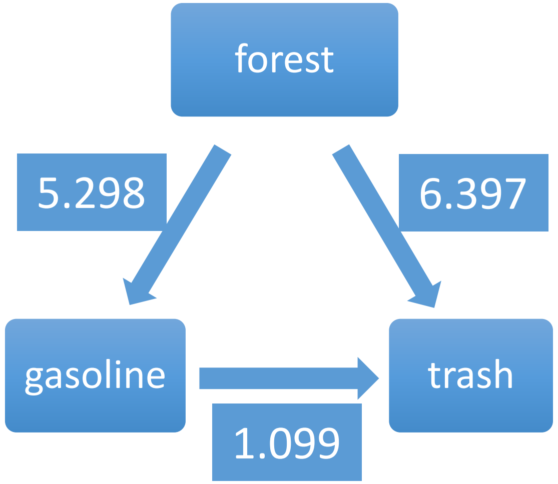




Just take logarithms on the edges, solve the additive variant, and exponentiate back

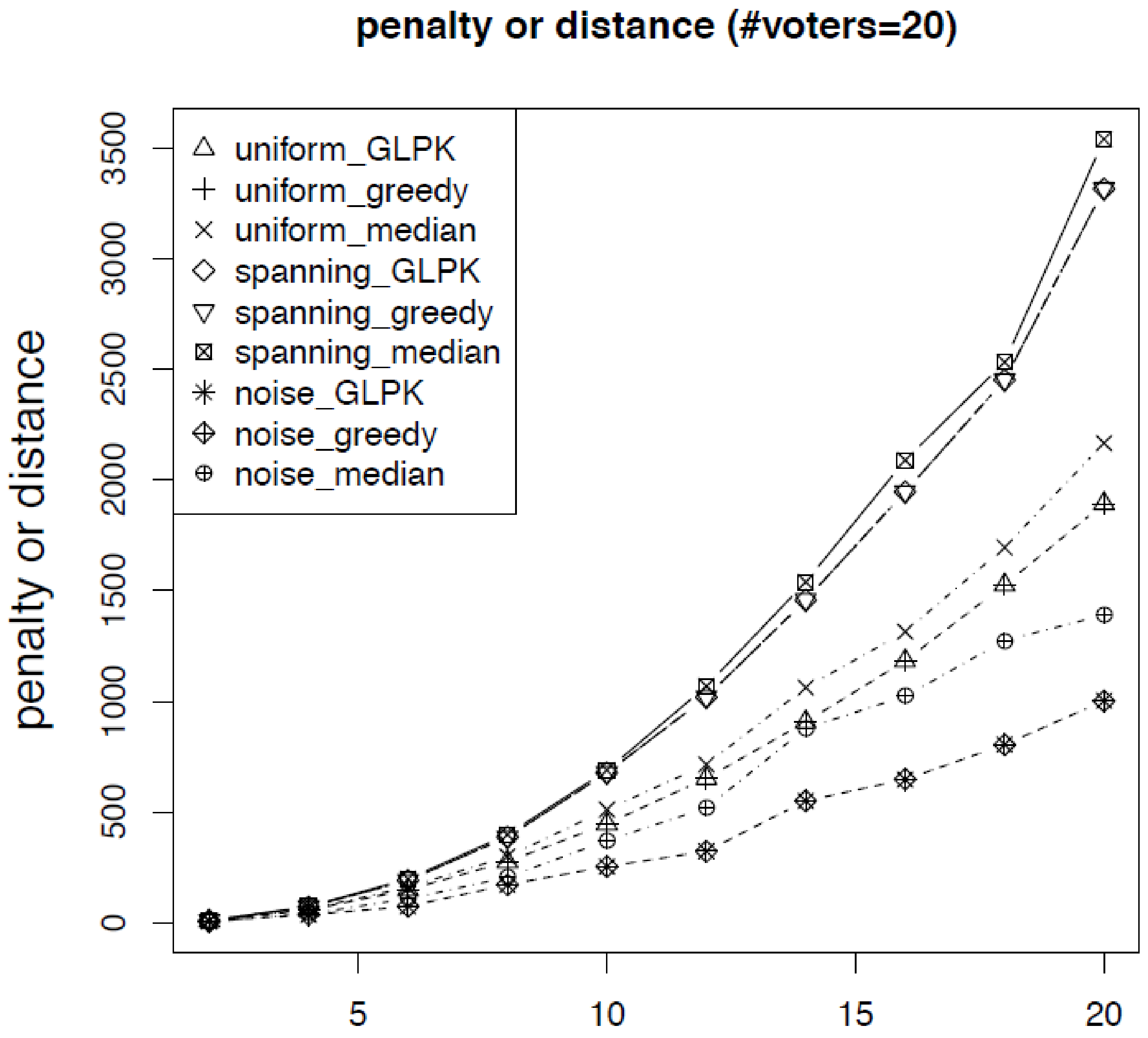




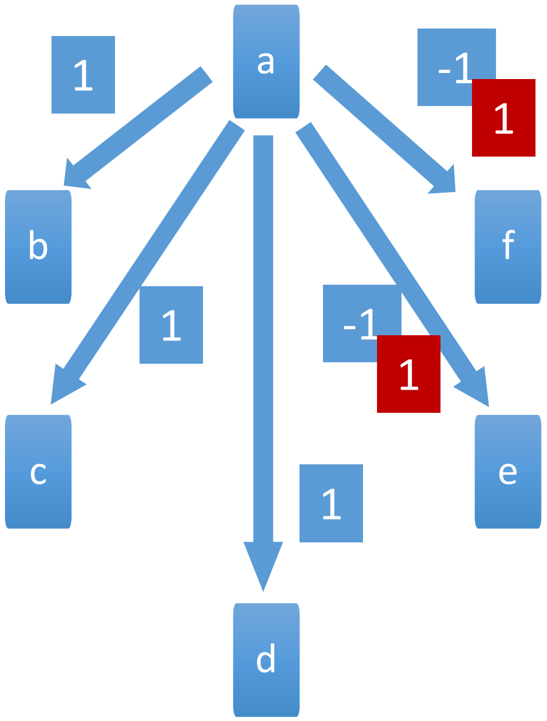


A simpler algorithm (hill climbing / greedy)

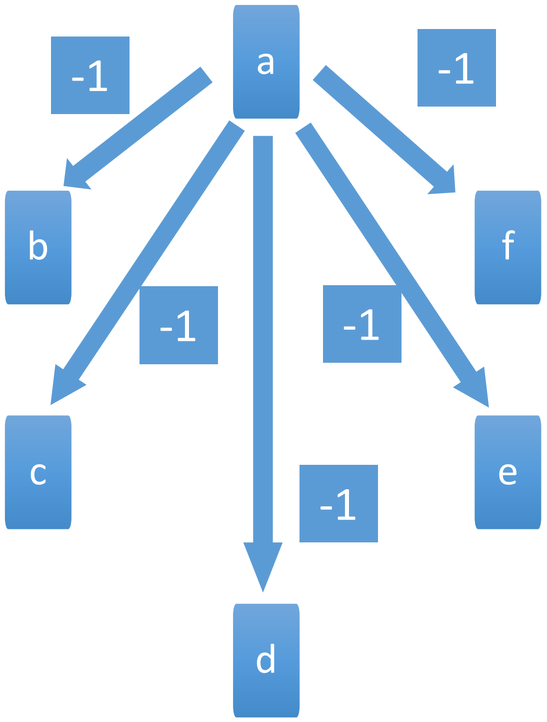
- Initialize qualities q_a arbitrarily
- If some q_a can be individually changed to improve the objective, do so
  - WLOG, set q_a to the median of the (#voters)*(#activities-1) implied votes on it
- Continue until convergence (possibly to local optimum)



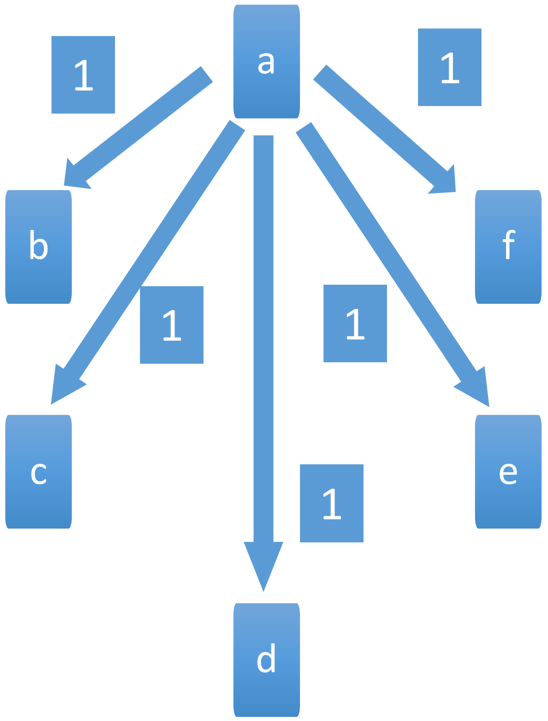
Strategy-proofness counterexample
(additive variant, missing edges implied by consistency)



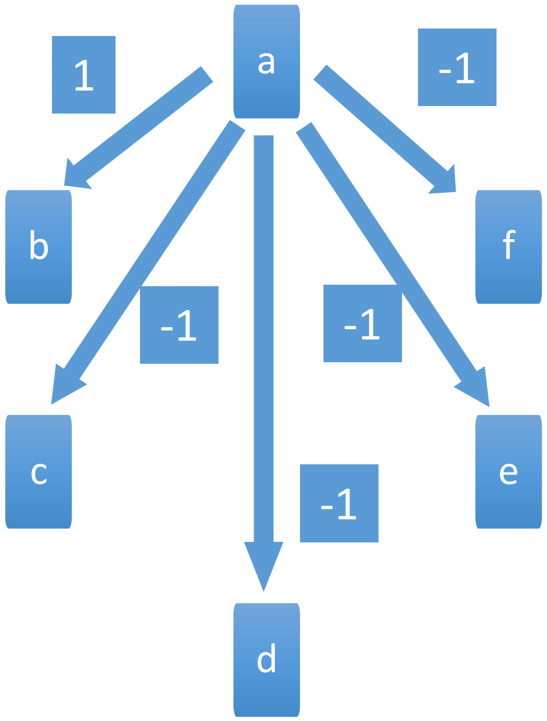
1 time



large number *k* times



large number *k* times



1 time

But: **Theorem**. Strategy-proofness holds when each agent only cares about and reports on one edge (not necessarily the same edge).

Other Issues

- Objective vs. subjective tradeoffs
  - separate process?
  - who determines which is which?
- Who gets to vote?
  - how to bring expert knowledge to bear?
  - incentives to participate
- Global vs. local tradeoffs
  - different entities (e.g., countries) may wish to reach their tradeoffs independently
  - only care about opinions of neighbors in my social network
- …

Relevant Topics

- social choice theory
  - voting
  - judgment aggregation
- game theory
- mechanism design
- prediction markets
- peer prediction
- preference elicitation
- …

Thank you for your attention!

Why Do We Care?

- Inconsistent tradeoffs can result in inefficiency
  - Agents optimizing their utility functions individually leads to solutions that are Pareto inefficient
- Pigovian taxes: pay the cost your activity imposes on society (the externality of your activity)
  - If we decided using 1 gallon of gasoline came at a cost of \$*x* to society, we could charge a tax of \$*x* on each gallon
  - But where would we get *x*?

Arthur Cecil Pigou

Inconsistent tradeoffs can result in inefficiency

- Agent 1: 1 gallon = 3 bags = -1 util
  - I.e., agent 1 feels she should be willing to sacrifice up to1 util to reduce trash by 3, but no more
- Agent 2: 1.5 gallons = 1.5 bags = -1 util
- Agent 3: 3 gallons = 1 bag = -1 util
- Cost of reducing gasoline by x is x^2 utils for each agent
- Cost of reducing trash by y is y^2 for each agent
- Optimal solutions for the individual agents:
  - Agent 1 will reduce by 1/2 and 1/6
  - Agent 2 will reduce by 1/3 and 1/3
  - Agent 3 will reduce by 1/6 and 1/2
- But if agents 1 and 3 each reduce everything by 1/3, the total reductions are the same, and their costs are 2/9 rather than 1/4 + 1/36 which is clearly higher.
  - Could then reduce slightly more to make everyone happier.

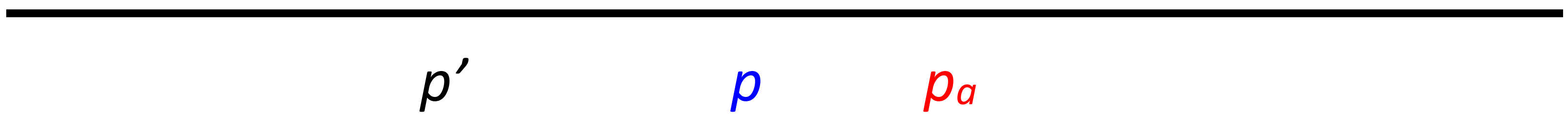
Single-peaked preferences

- *Definition:* Let agent *a*'s most-preferred value be p_a.

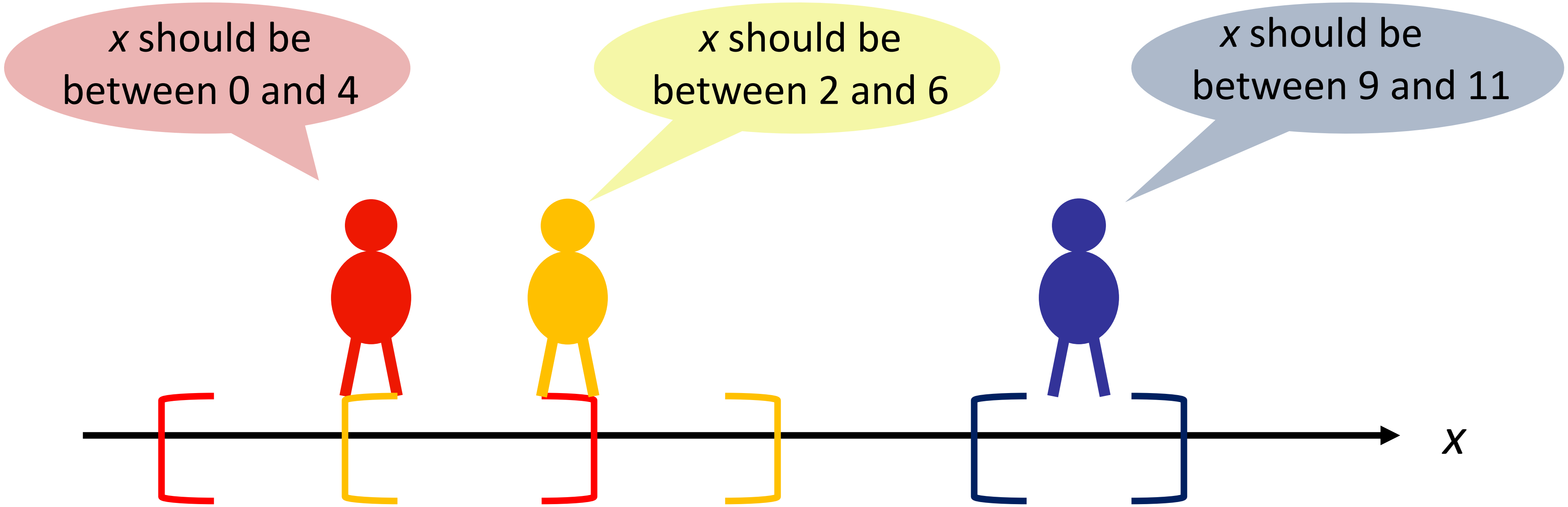
  Let p and p' satisfy:

  - $p' \leq p \leq p_a$, or $p_a \leq p \leq p'$

- The agent's preferences are single-peaked if the agent always weakly prefers p to p'



Perhaps more reasonable…

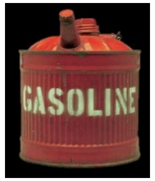


x should be between 0 and 4

x should be between 2 and 6

x should be between 9 and 11

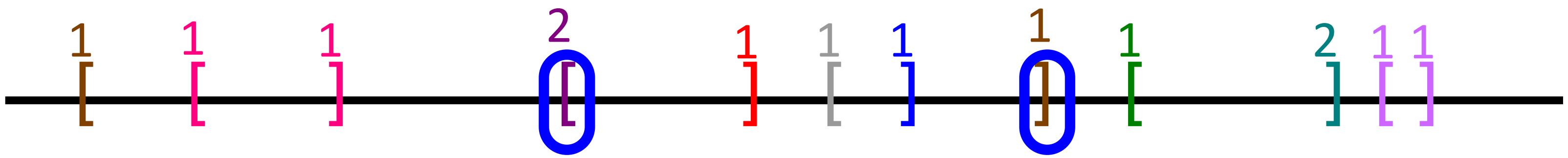
- E.g., due to missing information or plain uncertainty

1 = *x* 

- How to aggregate these interval votes? [Farfel & Conitzer 2011]

Median interval mechanism

- Construct a consensus interval from the median lower bound and the median upper bound



- Strategy-proof if preferences are single-peaked over intervals

Single-peaked preferences over intervals

- *Definition:* Let agent *a*'s most-preferred value interval be $P_a = [l_a, u_a]$.

  Let $S = [l, u]$ and $S' = [l', u']$ be any two value intervals satisfying the following constraints:

  - Either $l' \leq l \leq l_a$, or $l_a \leq l \leq l'$
  - Either $u' \leq u \leq u_a$, or $u_a \leq u \leq u'$

- The agent's preferences over intervals are single-peaked if the agent always weakly prefers *S* to *S'*