Lecture 2.

Wicked Problems

CS 222: AI Agents and Simulations

Stanford University

Joon Sung Park

Quickly: logistics

Announcements/FAQ

Interest form

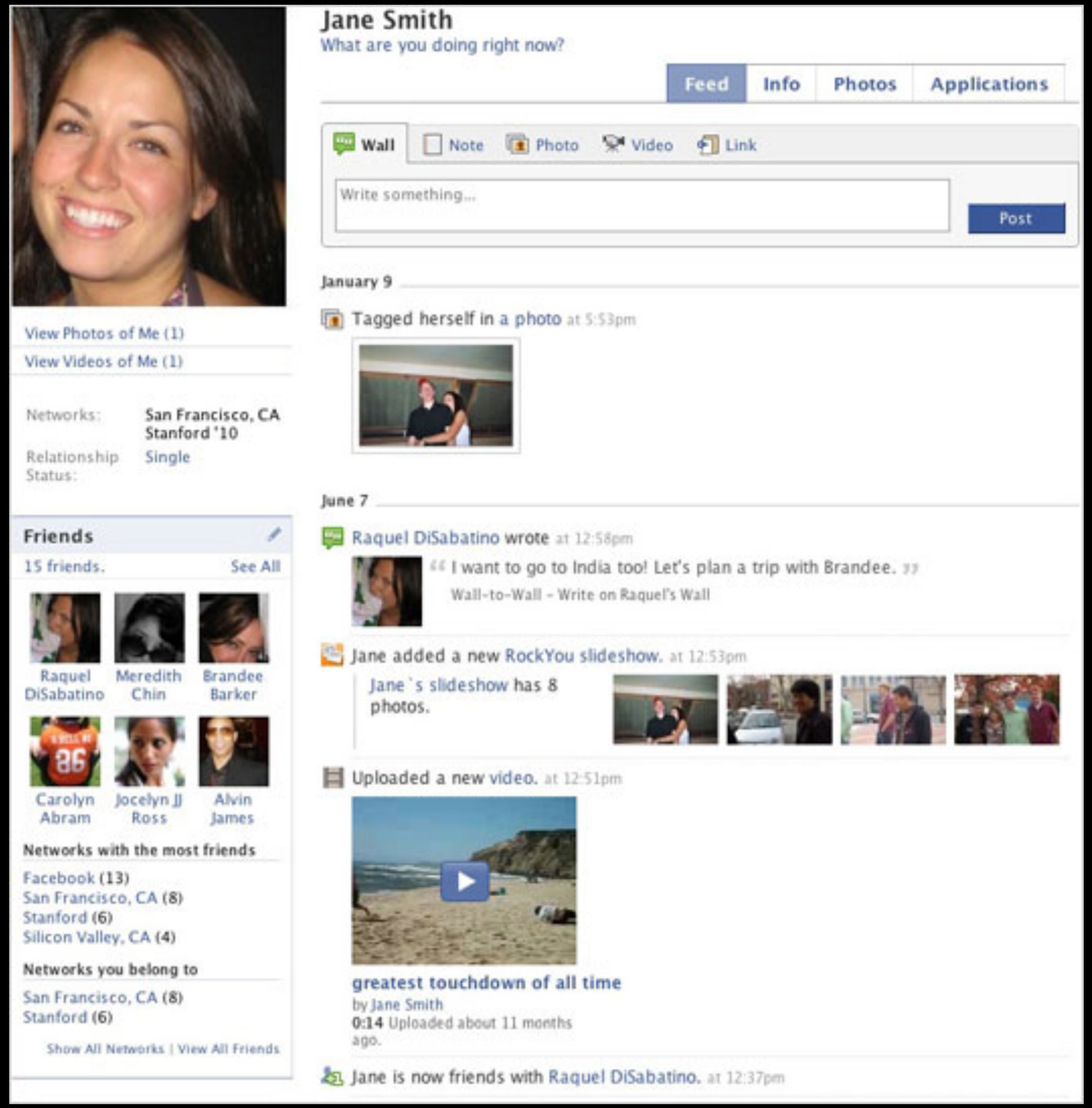
- We are negotiating with the department for CA funding and will provide an update asap.

Class audit policy

- I am okay with students auditing this course (e.g., if your schedule does not work out).
- Please feel free to attend the lectures or sit in the audience for project presentations.
- Course materials will be posted online.

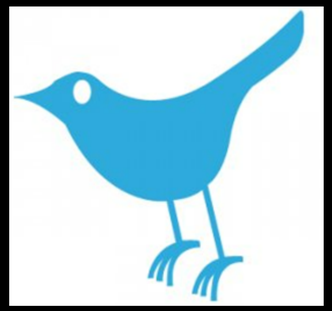
Vignettes for our imagination

Vignette 1: An SNS



B. Stone, Big changes coming to profile pages on Facebook. The New York Times (2008).

What problem did social media services face in the early days of the ecosystem?

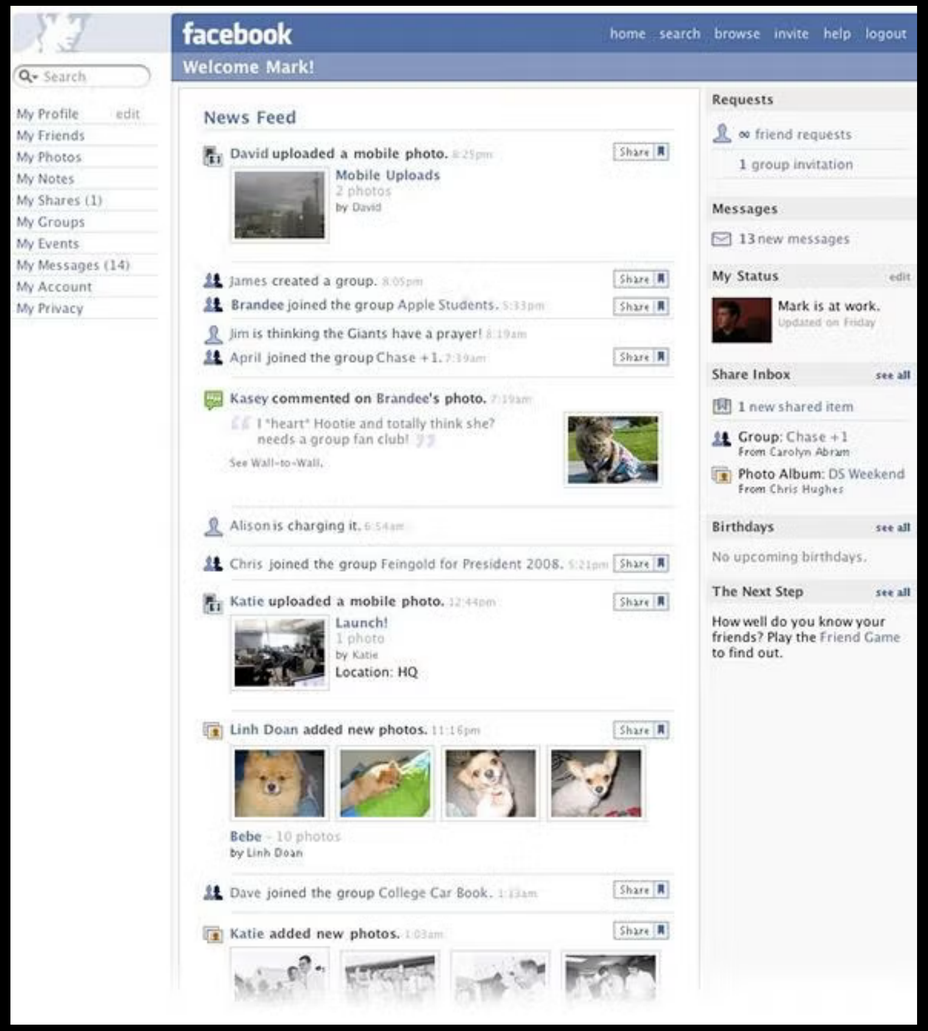


Problem 1: Winner takes all

Social media was a winner-takes-all space, where platforms needed to scale rapidly to become dominant or risk obsolescence.

Solution: Grow as fast as you can!

Solution concept: grab people's attention



Newsfeed

- In 2006, the News Feed and its algorithm were introduced, making it easier for users to see what their friends were doing.

Problem 2: Anti-social content spreads

An unintended consequence of the feed algorithm was the creation of an ecosystem where sensational, emotional, and often misleading content outperformed thoughtful or nuanced posts.

Solution: remove the anti-social content

Lazer, D. M., et al. (2018). The science of fake news. Science, 359(6380), 1094-1096.

Bail, C. A., et al. (2018). Exposure to opposing views on social media can increase political polarization. Proceedings of the National Academy of Sciences, 115(37), 9216-9221.

Solution concept: content moderation

Fact checkers

- Efforts to combat misinformation through fact-checking via expert fact-checkers propagated

Politifact, "Truth-O-Meter" (2021); https://www.politifact.com/.

Problem 3: Claims of bias or censorship

An unintended consequence of content moderation was exacerbating the underlying disagreement people had about what is true or false, leading to claims of bias and censorship against the social media platform.

V. Bergengruen, B. Perrigo, Facebook acted too late to tackle misinformation on 2020 election, report finds. Time (2021); https://time.com/5949210/facebook-misinformation-2020-election-report/.

Vignette 2: Pandemic response

What was the problem that government faced in the early days of pandemic response?

https://www.uab.edu/news/youcanuse/item/12313-feeling-covid-rage-five-strategies-for-managing-pandemic-anger

Problem 1: Spread of the illness

Governments have implemented lockdown policies in an effort to curb the spread of the pandemic.

Solution: Curb the spread of the illness

Solution concept: ask people to stay at home

Lockdown policy

- At the start of the pandemic, various governments implemented some form of stay-at-home or lockdown policies to mitigate the spread of the virus.

W. Yamaka, S. Lomwanawong, D. Magel, P. Maneejuk, Analysis of the lockdown effects on the economy, environment, and COVID-19 spread: lesson learnt from a global pandemic in 2020. PLoS One 17, e0268184 (2022); https://doi.org/10.1371/journal.pone.0268184.

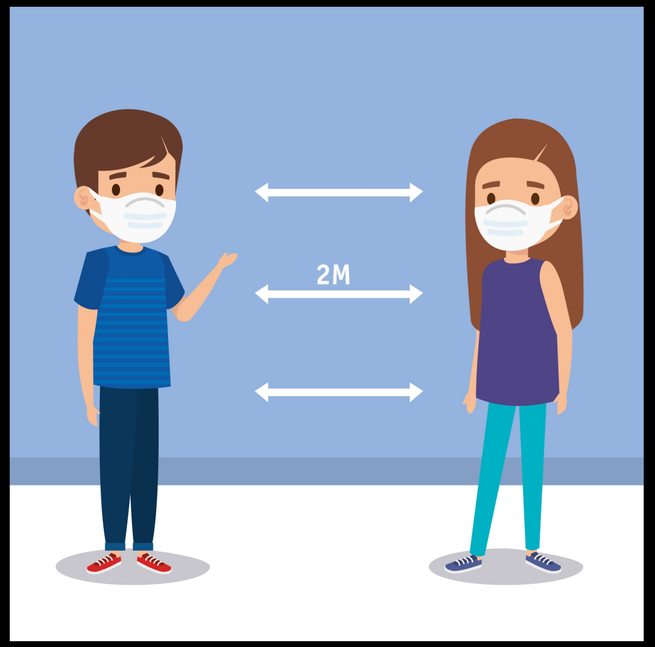
Problem 2: Negative economic impact

An unintended consequence of the lockdown policies was a statistically significant negative economic impact and a relatively muted effect on curbing the spread of the pandemic.

Solution: Undo the lockdown

W. Yamaka, S. Lomwanawong, D. Magel, P. Maneejuk, Analysis of the lockdown effects on the economy, environment, and COVID-19 spread: lesson learnt from a global pandemic in 2020. PLoS One 17, e0268184 (2022); https://doi.org/10.1371/journal.pone.0268184.

Solution concept: ask people to go back to work



Social distancing

- Various governments relaxed lockdown policies, asking people to return to work while practicing social distancing.

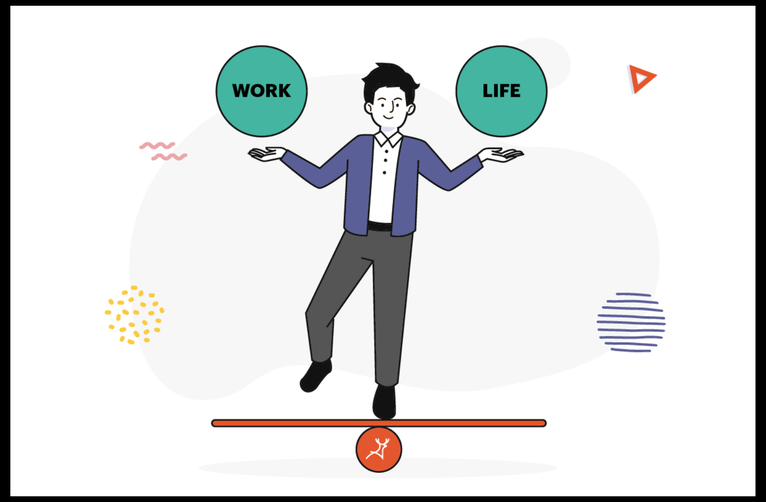
Problem 3: Drop in public trust

An unintended consequence of the weak economy and fluctuating policies was a decline in public trust in the government, which contributed to the initial challenges in ensuring that people got vaccinated.

L. Privor-Dumm, J. Excler, S. Gilbert, S. S. Abdool Karim, P. J. Hotez, D. Thompson, J. H. Kim, Vaccine access, equity and justice: COVID-19 vaccines and vaccination. BMJ Glob. Health 8, e011881 (2023). https://doi.org/10.1136/bmjgh-2023-011881.

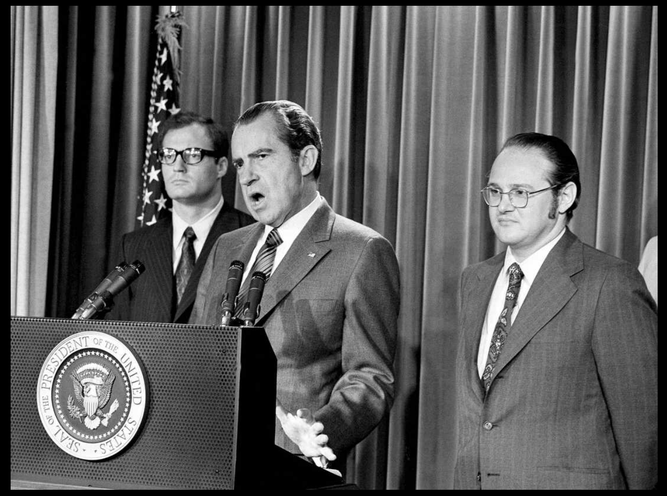
S. Ruiz, U. C. Okere, M. Eggers, C. O'Leary, M. Politi, F. Wan, A. J. Housten, Eliciting opinions on health messaging during the COVID-19 pandemic: qualitative survey study. JMIR Hum. Factors **10**, e39697 (2023). https://doi.org/10.2196/39697.

Challenges of this shape and form are everywhere.

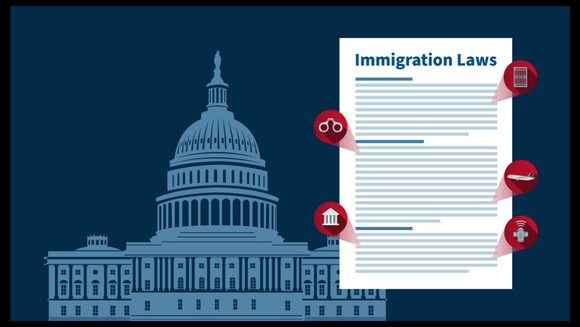


Work life balance

Sustainability



War against drugs



Immigration policy

Universal healtcare

Themes

Do you think our institutions did the “right thing”?

Wicked problems

What problems can simulations uniquely help us address?

Horst W. J. Rittel

Melvin M. Webber

Policy Sciences **4** (1973), 155–169

Dilemmas in a General Theory of Planning*

HORST W. J. RITTEL
Professor of the Science of Design, University of California, Berkeley

MELVIN M. WEBBER
Professor of City Planning, University of California, Berkeley

ABSTRACT

The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature of these problems. They are "wicked" problems, whereas science has developed to deal with "tame" problems. Policy problems cannot be definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions" to social problems unless severe qualifications are imposed first. Even worse, there are no "solutions" in the sense of definitive and objective answers.

George Bernard Shaw diagnosed the case several years ago; in more recent times popular protest may have already become a social movement. Shaw averred that "every profession is a conspiracy against the laity." The contemporary publics are responding as though they have made the same discovery.

Few of the modern professionals seem to be immune from the popular attack—whether they be social workers, educators, housers, public health officials, policemen, city planners, highway engineers or physicians. Our restive clients have been telling us that they don't like the educational programs that schoolmen have been offering, the redevelopment projects urban renewal agencies have been proposing, the law-enforcement styles of the police, the administrative behavior of the welfare agencies, the locations of the highways, and so on. In the courts, the streets, and the political campaigns, we've been hearing ever-louder public protests against the professions' diagnoses of the clients' problems, against professionally designed governmental programs, against professionally certified standards for the public services.

It does seem odd that this attack should be coming just when professionals in

* This is a modification of a paper presented to the Panel on Policy Sciences, American Association for the Advancement of Science, Boston, December 1969.

Wicked problems are complex, ill-defined social or policy challenges that defy straightforward solutions.

H. W. J. Rittel, M. M. Webber, Dilemmas in a general theory of planning. Policy Sciences 4, 155-169 (1973).

What makes this hard to address?

- There is no definitive formulation of a wicked problem (problem formulation is just as important).
- Wicked problems have no stopping rule.
- Solutions to wicked problems are not true-or-false, but better or worse.
- There is no immediate and no ultimate test of a solution to a wicked problem.
- Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial and error, every attempt counts significantly.
- Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
- Every wicked problem is essentially unique.

Exercise 1. SNS

- There is no definitive formulation of a wicked problem (problem formulation is just as important).
- Wicked problems have no stopping rule.
- Solutions to wicked problems are not true-or-false, but better or worse.
- There is no immediate and no ultimate test of a solution to a wicked problem.
- Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial and error, every attempt counts significantly.
- Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
- Every wicked problem is essentially unique.

Exercise 2. Pandemic response

- There is no definitive formulation of a wicked problem (problem formulation is just as important).
- Wicked problems have no stopping rule.
- Solutions to wicked problems are not true-or-false, but better or worse.
- There is no immediate and no ultimate test of a solution to a wicked problem.
- Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial and error, every attempt counts significantly.
- Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
- Every wicked problem is essentially unique.

History:

Wicked problems, design, and AI

Rittel and Webber provide a foundation for studying “design”

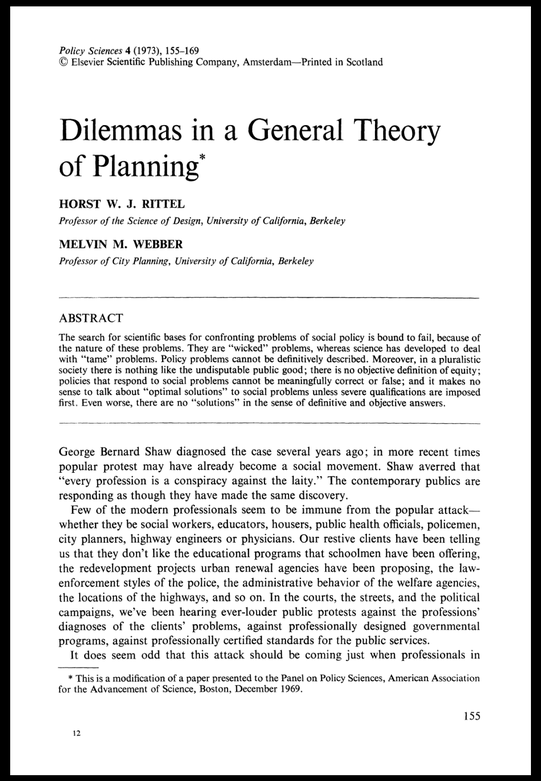
Horst W. J. Rittel

Rittel was a design theorist at UC Berkeley.

Melvin M. Webber

Webber was an urban designer and theorist at UC Berkeley.

The problems of design distinguish themselves from those of science.



Policy Sciences 4 (1973), 155–169

Dilemmas in a General Theory of Planning*

HORST W. J. RITTEL
Professor of the Science of Design, University of California, Berkeley

MELVIN M. WEBBER
Professor of City Planning, University of California, Berkeley

ABSTRACT

The search for scientific bases for confronting problems of social policy is bound to fail, because of the nature of these problems. They are "wicked" problems, whereas science has developed to deal with "tame" problems. Policy problems cannot be definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions" to social problems unless severe qualifications are imposed first. Even worse, there are no "solutions" in the sense of definitive and objective answers.

George Bernard Shaw diagnosed the case several years ago; in more recent times popular protest may have already become a social movement. Shaw averred that "every profession is a conspiracy against the laity." The contemporary publics are responding as though they have made the same discovery.

Few of the modern professionals seem to be immune from the popular attack—whether they be social workers, educators, housers, public health officials, policemen, city planners, highway engineers or physicians. Our restive clients have been telling us that they don't like the educational programs that schoolmen have been offering, the redevelopment projects urban renewal agencies have been proposing, the law-enforcement styles of the police, the administrative behavior of the welfare agencies, the locations of the highways, and so on. In the courts, the streets, and the political campaigns, we've been hearing ever-louder public protests against the professions' diagnoses of the clients' problems, against professionally designed governmental programs, against professionally certified standards for the public services.

It does seem odd that this attack should be coming just when professionals in

* This is a modification of a paper presented to the Panel on Policy Sciences, American Association for the Advancement of Science, Boston, December 1969.

The kinds of problems that planners deal with—societal problems—are inherently different from the problems that scientists and perhaps some classes of engineers deal with Planning problems are inherently wicked

As distinguished from problems in the natural sciences, which are definable and separable and may have solutions that are findable, the problems of governmental planning—and especially those of social or policy planning—are ill-defined, and they rely upon elusive political judgment for resolution (Not "solution" Social problems are never solved At best they are only re-solved—over and over again) Permit us to draw a cartoon that will help clarify the distinction we intend

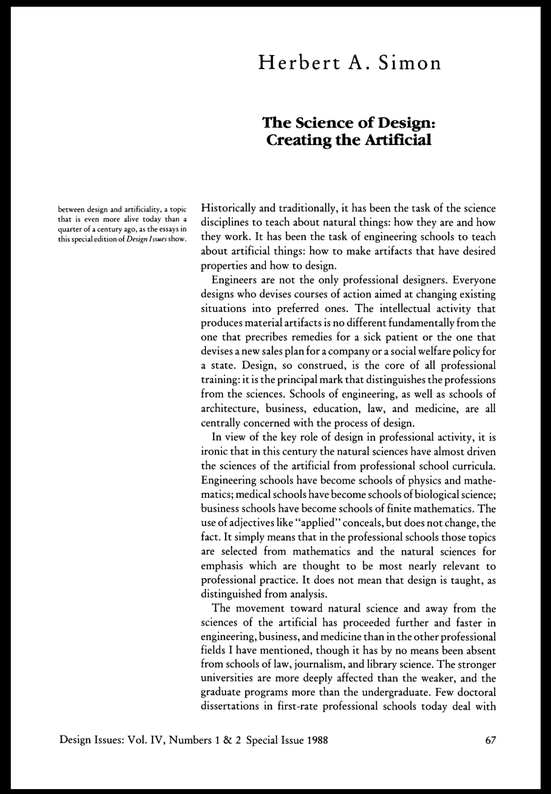
The problems that scientists and engineers have usually focused upon are mostly "tame" or "benign" ones As an example, consider a problem of mathematics, such as solving an equation, or the task of an organic chemist in analyzing the structure of some unknown compound, or that of the chessplayer attempting to accomplish checkmate in five moves For each the mission is clear It is clear, in turn, whether or not the problems have been solved

Wicked problems, in contrast, have neither of these clarifying traits, and they include nearly all public policy issues—whether the question concerns the location of a freeway, the adjustment of a tax rate, the modification of school curricula, or the confrontation of crime

H. W. J. Rittel, M. M. Webber, Dilemmas in a general theory of planning. Policy Sciences 4, 155-169 (1973).

This study of design inspires the founders of AI and HCI

Herbert A. Simon



Herbert A. Simon

The Science of Design: Creating the Artificial

between design and artificiality, a topic that is even more alive today than a quarter of a century ago, as the essays in this special edition of *Design Issues* show.

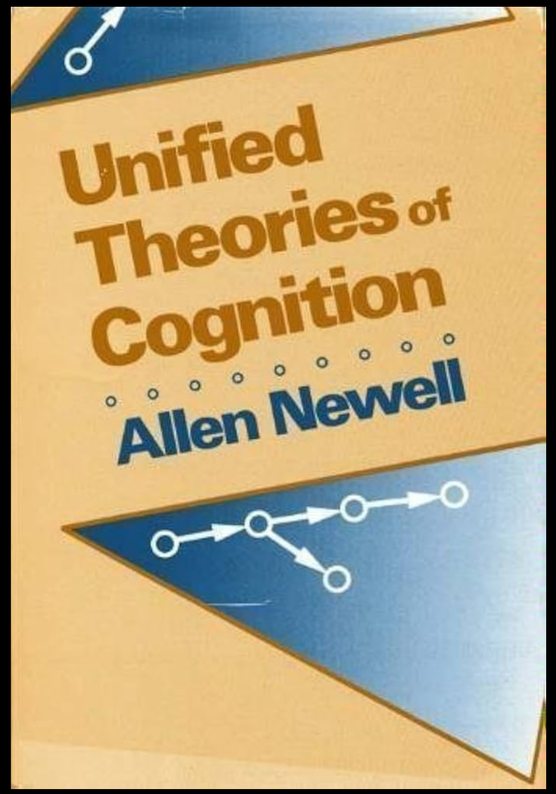
Historically and traditionally, it has been the task of the science disciplines to teach about natural things: how they are and how they work. It has been the task of engineering schools to teach about artificial things: how to make artifacts that have desired properties and how to design.

Engineers are not the only professional designers. Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artifacts is no different fundamentally from the one that precribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state. Design, so construed, is the core of all professional training: it is the principal mark that distinguishes the professions from the sciences. Schools of engineering, as well as schools of architecture, business, education, law, and medicine, are all centrally concerned with the process of design.

In view of the key role of design in professional activity, it is ironic that in this century the natural sciences have almost driven the sciences of the artificial from professional school curricula. Engineering schools have become schools of physics and mathematics; medical schools have become schools of biological science; business schools have become schools of finite mathematics. The use of adjectives like "applied" conceals, but does not change, the fact. It simply means that in the professional schools those topics are selected from mathematics and the natural sciences for emphasis which are thought to be most nearly relevant to professional practice. It does not mean that design is taught, as distinguished from analysis.

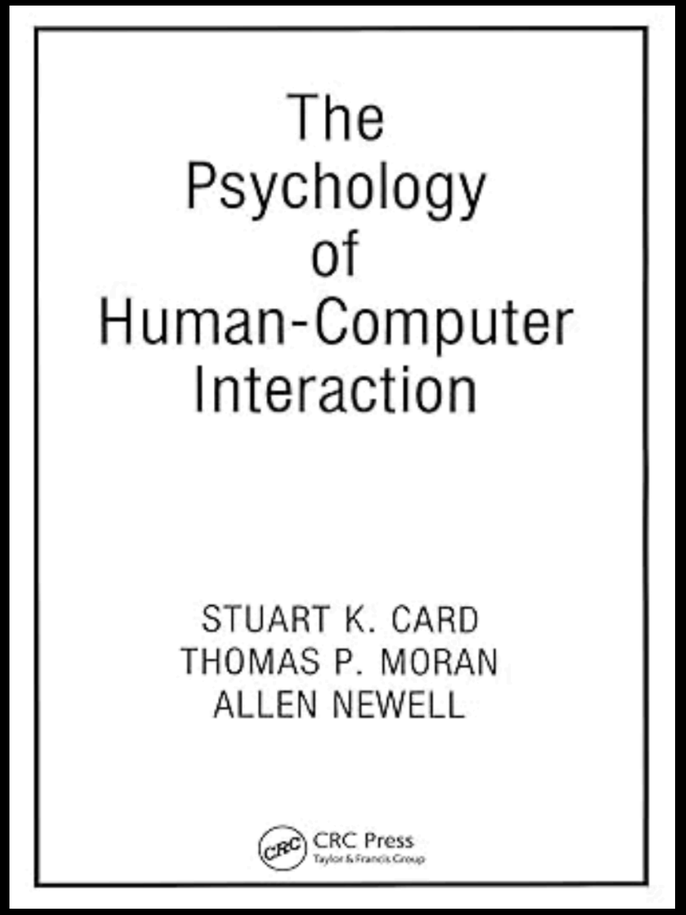
The movement toward natural science and away from the sciences of the artificial has proceeded further and faster in engineering, business, and medicine than in the other professional fields I have mentioned, though it has by no means been absent from schools of law, journalism, and library science. The stronger universities are more deeply affected than the weaker, and the graduate programs more than the undergraduate. Few doctoral dissertations in first-rate professional schools today deal with

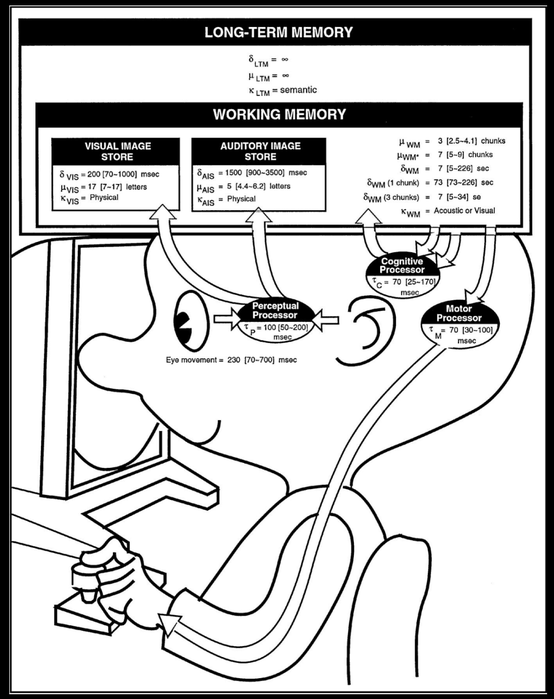
Allen Newell



H. Simon, The Science of Design: Creating the Artificial (MIT Press, 1996).
A. Newell, Unified Theories of Cognition (Harvard University Press, 1990).

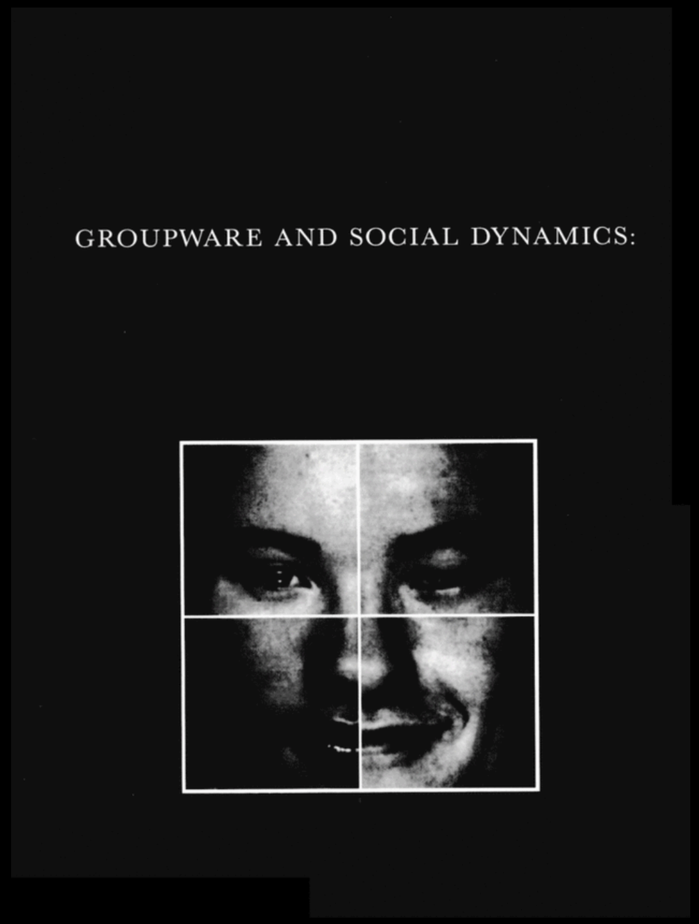
This study of design inspires the founders of AI and HCI





S. K. Card, T. P. Moran, A. Newell, The Psychology of Human-Computer Interaction (Lawrence Erlbaum Associates, 1983).

Design and engineering tackle soft-edged problems.



J. Grudin, Groupware and social dynamics: eight challenges for developers. Commun. ACM 37, 92–105 (1994).

The shape of our solution

Many now have an image of *how* an *idealized* planning system would function It is being seen as an on-going, cybernetic process of governance, incorporating systematic procedures for continuously searching out goals, identifying problems, forecasting uncontrollable contextual changes, inventing alternative strategies, tactics, and time-sequenced actions, stimulating alternative and plausible action sets and their consequences, evaluating alternatively forecasted outcomes, statistically monitoring those conditions of the publics and of systems that are judged to be germane, feeding back information to the simulation and decision channels so that errors can be corrected—all in a simultaneously functioning governing process That set of steps is familiar to all of us, for it comprises what is by now the modern-classical model of planning And yet we all know that such a planning system is unattainable, even as we seek more closely to approximate it

H. W. J. Rittel, M. M. Webber, Dilemmas in a general theory of planning. Policy Sciences 4, 155-169 (1973).

Wicked problems are recursive in nature.

8. Every wicked problem can be considered to be a symptom of another problem

Problems can be described as discrepancies between the state of affairs as it is and the state as it ought to be The process of resolving the problem starts with the search for causal explanation of the discrepancy Removal of that cause poses another problem of which the original problem is a "symptom " In turn, it can be considered the symptom of still another, "higher level" problem Thus "crime in the streets" can be considered as a symptom of general moral decay, or permissiveness, or deficient opportunity, or wealth, or poverty, or whatever causal explanation you happen to like best The level at which a problem is settled depends upon the self-confidence of the analyst and cannot be decided on logical grounds There is nothing like a natural level of a wicked problem Of course, the higher the level of a problem's formulation, the broader and more general it becomes and the more difficult it becomes to do something about it On the other hand, one should not try to cure symptoms and therefore one should try to settle the problem on as high a level as possible

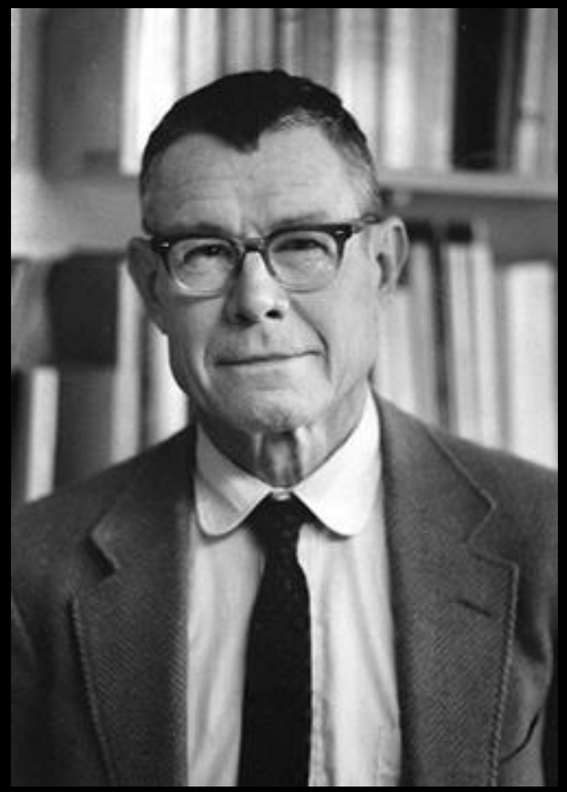
Here lies a difficulty with incrementalism, as well This doctrine advertises a policy of small steps, in the hope of contributing systematically to overall improvement If, however, the problem is attacked on too low a level (an increment), then success of resolution may result in making things worse, because it may become more difficult to deal with the higher problems Marginal improvement does not guarantee overall improvement For example, computerization of an administrative process may result in reduced cost, ease of operation, etc But at the same time it becomes more difficult to incur structural changes in the organization, because technical perfection reinforces organizational patterns and normally increases the cost of change The newly acquired power of the controllers of information may then deter later modifications of their roles

Under these circumstances it is not surprising that the members of an organization tend to see the problems on a level below their own level If you ask a police chief what the problems of the police are, he is likely to demand better hardware

Can simulations help us identify the most general versions of our problems?

H. W. J. Rittel, M. M. Webber, Dilemmas in a general theory of planning. Policy Sciences 4, 155-169 (1973).

Schelling's Model

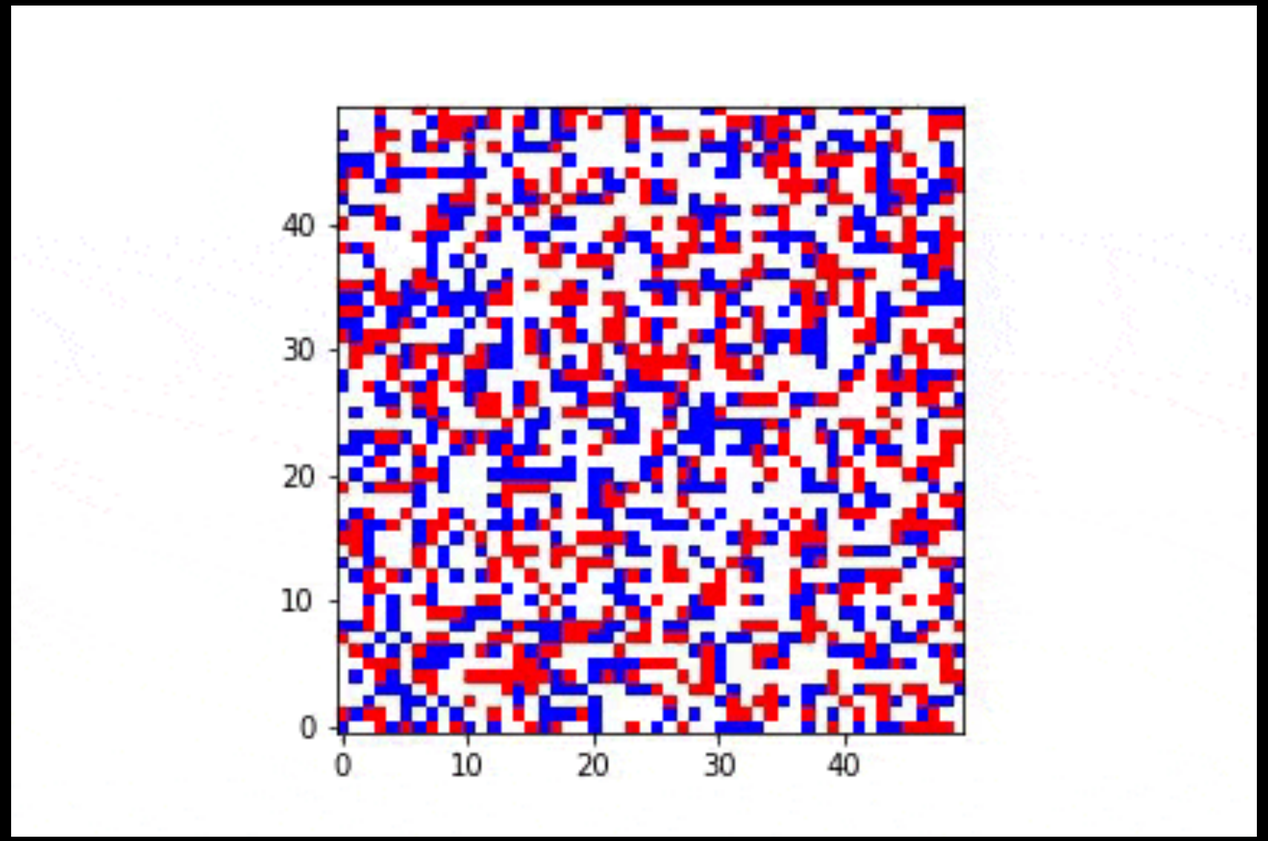


Thomas Schelling

Schelling was an economist at University of Maryland, College Park

T. C. Schelling, Micromotives and Macrobehavior (W.W. Norton & Company, 1978).

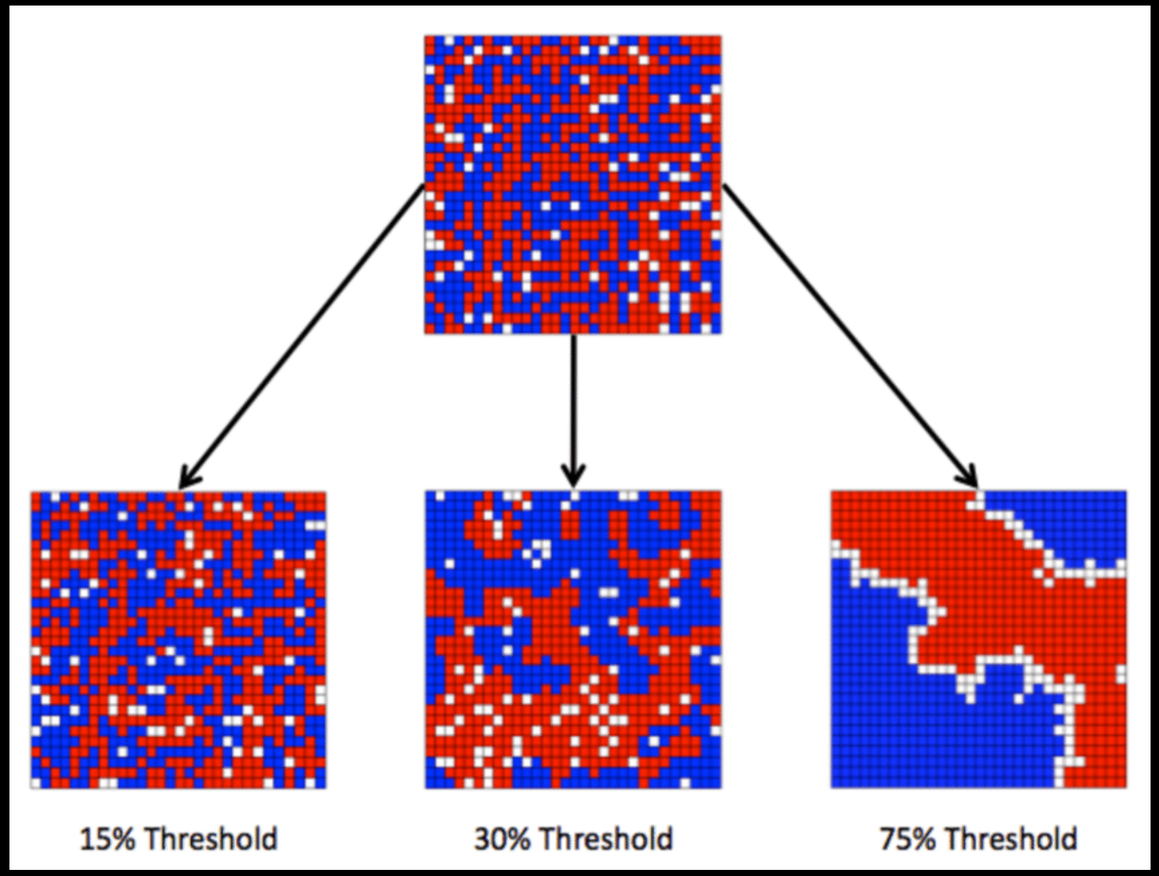
Schelling's model of human behavior aims to explain how human interactions lead to complex outcomes.



Model of Segregation

T. C. Schelling, Dynamic models of segregation. J. Math. Sociol. 1, 143–186 (1971).

Schelling demonstrates the “tipping point.”



T. C. Schelling, Dynamic models of segregation. J. Math. Sociol. 1, 143–186 (1971).

Generational challenges

What would it take for the field of simulation to earn a Nobel Prize?

References

- B. Stone, Big changes coming to profile pages on Facebook. The New York Times (2008).
- Lazer, D. M., et al. (2018). The science of fake news. Science, 359(6380), 1094-1096.
- Bail, C. A., et al. (2018). Exposure to opposing views on social media can increase political polarization. Proceedings of the National Academy of Sciences, 115(37), 9216-9221.
- Politifact, "Truth-O-Meter" (2021); https://www.politifact.com/.
- V. Bergengruen, B. Perrigo, Facebook acted too late to tackle misinformation on 2020 election, report finds. Time (2021); https://time.com/5949210/facebook-misinformation-2020-election-report/.
- W. Yamaka, S. Lomwanawong, D. Magel, P. Maneejuk, Analysis of the lockdown effects on the economy, environment, and COVID-19 spread: lesson learnt from a global pandemic in 2020. PLoS One 17, e0268184 (2022); https://doi.org/10.1371/journal.pone.0268184.
- L. Privor-Dumm, J. Excler, S. Gilbert, S. S. Abdool Karim, P. J. Hotez, D. Thompson, J. H. Kim, Vaccine access, equity and justice: COVID-19 vaccines and vaccination. BMJ Glob. Health 8, e011881 (2023). https://doi.org/10.1136/bmjgh-2023-011881.

References

- S. Ruiz, U. C. Okere, M. Eggers, C. O'Leary, M. Politi, F. Wan, A. J. Housten, Eliciting opinions on health messaging during the COVID-19 pandemic: qualitative survey study. JMIR Hum. Factors 10, e39697 (2023). https://doi.org/10.2196/39697.
- H. W. J. Rittel, M. M. Webber, Dilemmas in a general theory of planning. Policy Sciences 4, 155-169 (1973).
- H. Simon, The Science of Design: Creating the Artificial (MIT Press, 1996).
- A. Newell, Unified Theories of Cognition (Harvard University Press, 1990).
- S. K. Card, T. P. Moran, A. Newell, The Psychology of Human-Computer Interaction (Lawrence Erlbaum Associates, 1983).
- J. Grudin, Groupware and social dynamics: eight challenges for developers. Commun. ACM 37, 92–105 (1994).
- T. C. Schelling, Micromotives and Macrobehavior (W.W. Norton & Company, 1978).
- T. C. Schelling, Dynamic models of segregation. J. Math. Sociol. 1, 143–186 (1971).

CS 222: AI Agents and Simulations

Stanford University

Joon Sung Park