

# Robotics and Autonomous Systems

## Lecture 29: Application of Agents

Richard Williams

Department of Computer Science  
University of Liverpool



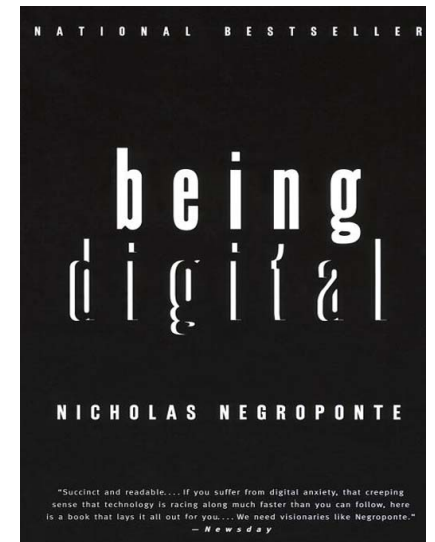
- In this final lecture we will look at applications.
- Places where agents are used in real world applications.
- Or close to real world applications.

## Domains suited for MAS applications

- Domains where resources (e.g., data, expertise) and/or control (e.g., processes) are distributed
- Domains where centralized control is impractical
- Domains where processes have competing objectives ... all these require some level of **intelligence** and **autonomy**

## Interface agents

“The ‘agent’ answers the phone, recognises the callers, disturbs you when appropriate, and may even tell a white lie on your behalf. The same agent is well trained in timing, versed in finding opportune moments, and respectful of idiosyncracies.”  
(p150)



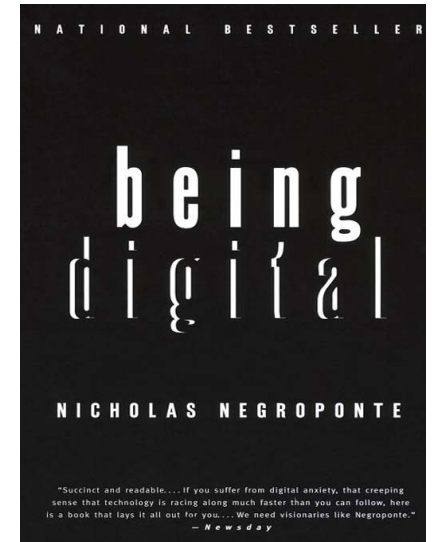
## Interface agents

“If you have somebody who knows you well and shares much of your information, that person can act on your behalf very effectively. If your secretary falls ill, it would make no difference if the temping agency could send you Albert Einstein. This issue is not about IQ. It is shared knowledge and the practice of using it in your best interests.”  
(p151)

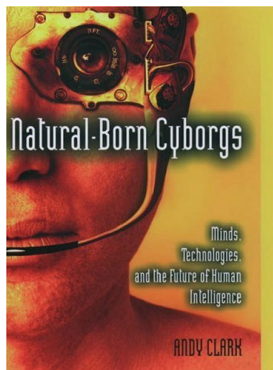


## Interface agents

“Like an army commander sending a scout ahead . . . you will dispatch agents to collect information on your behalf. Agents will dispatch agents. The process multiplies. But [this process] started at the interface where you delegated your desires.”  
(p158)



## Natural-born cyborgs?



“The drive toward biotechnological merger is deep within us”

## Natural-born cyborgs?



## Mental prostheses

- While physical prostheses will play a role, mental prostheses will be much more widespread.
  - Ways to boost our knowledge/memory/processing capabilities
- No radical surgery necessary.
- In fact we already rely on such mental prostheses.

## Mental Prostheses

- How do you answer the question:  
“Do you know what the time is?”
- How do you answer the question:  
“Do you know what **hymeneal** means?”
- How do you answer the question:  
“Do you know the best route from Liverpool to Oxford?”
- What is the real reason you aren't paying attention to what I'm saying?

## Mental Prostheses

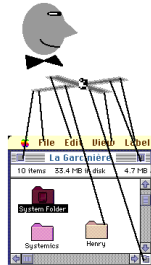


## Mental Prostheses



## Interface agents

- Agents are assistants rather than tools
- They have information about their users and can anticipate their needs to a greater degree than more commonly used software



## Interface agents

- MAXIM: email assistant developed by Pattie Maes at MIT Media Lab.
- It learns to prioritize, delete, forward, sort and archive mail messages on behalf of a user.
- MAXIM is able to assess the confidence of its own actions and, based on user-set thresholds, it either acts or notifies the user beforehand acting.
- (Not so far removed from auto-completion).

## Agents in eCommerce

- eCommerce has flourished after the development of solutions addressing key issues for carrying out monetary transactions over the internet
  - Trust/reliability of vendors and customers
  - Privacy and security of personal information
- Success stories: Amazon, eBay
- Vision: automatization of shopping activities:
  - Finding deals
  - Bidding & negotiating
  - Finalizing transactions with vendors on behalf of the user possibly involving negotiation

## ShopBots

- Classic shopping agents
- Bargain Finder by Andersen (1995)
- Jango by NetBot (1997)
  - First commercial internet price comparison service
  - Could collect specifications and reviews, compare for the best buy.
  - It exploited regularities in the webpages of vendors to find relevant information
- Froogle (2003)
  - Now called Google Product Search

## Product Search

Clear all filters

£20 - £35

Sort: Relevance ▾ View: List ▾

Cookies help us deliver our services. By using our services, you agree to our use of cookies. [Learn more](#)

Livepool, UK

Show only:  New items

Price:  -

Category:  Stovetop Espresso Pot

Brand:  Kitchen Craft  Bialetti  Alessi  La Caltanissetta  CucinaFluo

Seller:  eBay  Gals Coffee  Overstock.com  Mart's  eBay - galacoffee  More

**Bialetti Versus Induction Stove-top Coffee Maker**  
 £30.40 from 4 shops  In stock nearby  
 ★★★★★ (3) product reviews  
 Sleek contemporary yet functional Versus espresso coffee makers - La Caltanissetta UK - Espresso Cup = 240ml (approx)

**Bialetti ES090200 Moka Express 9 Cup Espresso Maker**  
 £28.00    
 ★★★★★ (45) product reviews  
 Bialetti Moka 9 Cup espresso maker. Traditional Italian design, put you water in the middle then put it on the stove, the water boils, steaming ... more

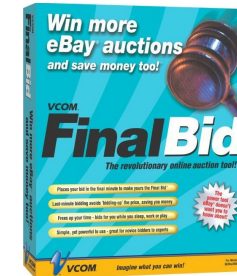
**Bialetti Engano Versus Induction 4 Cup**  
 £21.95 from 3 shops  
 ★★★★★ (3) product reviews  
 ES090400 Espresso Maker - versus induction 4 cup Material 1810 Stainless steel Sleek - contemporary and functional Stainless Steel material A black ...

**Bialetti Brikka Espresso Maker 2 Cup**  
 £33.75 from 2 shops  
 ★★★★★ (6) product reviews  
 The Brikka Espresso maker, from Bialetti, has all the features of the original Moka Express but with an extra feature. It contains a special valve ...

17/39

## ShopBots

- Bidding agents for eBay.

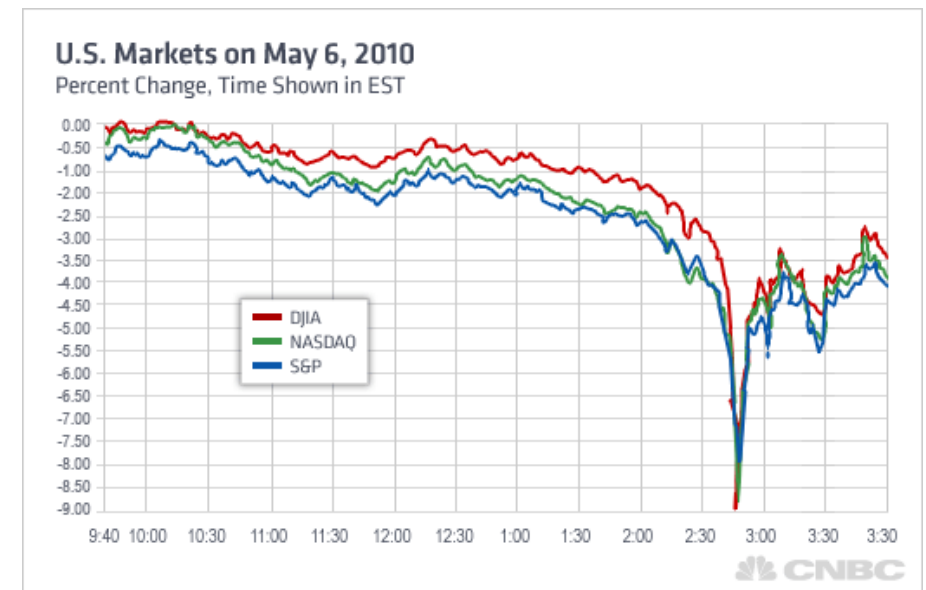


- Try to ensure that you “steal the deal” at the last minute.
- Bidding agents for ad auctions.

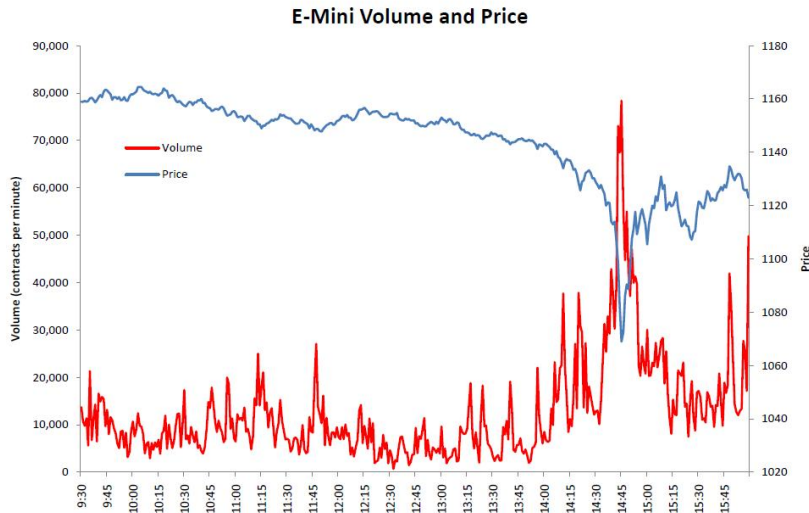
## High-Frequency Trading

- Software agents are heavily deployed in the stock market as automatic traders
- They collect relevant information, process it at high speed (in the order of milliseconds), and act upon it by trading stocks
- They are particularly useful for arbitrage (exploiting difference in prices for the same stock/goods in different markets)
- In 2009, more than 70% of the US trading volume in equities was carried out by automatic traders
- They are believed to have played a role in the 6th May 2010 so-called Flash Crash (Dow Jones lost 9% value in 5 min, recovering it later just about as fast)

## Flash Crash



## Flash Crash



19

May 6, 2010 Market Event Findings

21 / 39



22 / 39

## Business Process Management

- A business organization is modeled as a set of interacting agents
- Their activities contribute to business processes but cut across them
- Finer level of granularity, higher flexibility than a centralized workflow system
- Example: ADEPT (used the PRS architecture)

## SmartGrid

- Current challenges for electricity networks:
  - Increasing electricity demand
  - Decreasing controllability of power sources (Renewable energy)
  - Increasing low and middle power generation units (Households)
- This calls for:
  - Coordination between (small and large) producers
  - 2-way communication from producers and consumers



23 / 39

## Virtual environments



24 / 39

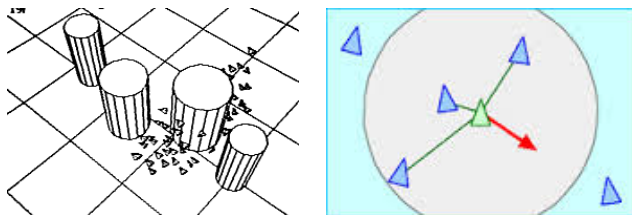
## Virtual agents



## Agent-based modelling

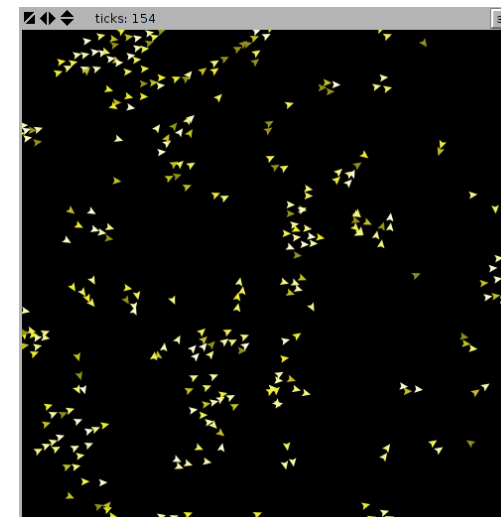
- ABM is a modeling method (platform-independent) for complex systems (e.g., crowds, markets, populations)
- It is particularly suited for modeling emergent phenomena
- These are properties of systems that depend on their components and their dynamic interactions
- Systems are represented as collections of repetitively interacting autonomous decision-makers (agents)
- We look at some examples:
  - Flow (e.g., crowd control, evacuation situations, traffic)
  - Market modeling (e.g., stock market, monetary market)
  - Epidemics modeling (e.g., diseases, innovation)

## Flocking



- Simple rules control a swarm of artificial “boids”

## Flocking in action



## Flocking in action



## Crowd modelling

- Crowd management is critical for the organization of large events (sport events, concerts, rallies, etc.).
- Crowds, in stress situations, might exhibit so-called herding effects
  - Individual short-term behavior (e.g., by panic) is replicated and spreads rapidly within a group.
- Herding behavior is often the prime source of danger for the individual members of the crowd.
- ABS can provide reliable models of crowd behavior for the design of viable (but often counterintuitive) solutions in situations of emergency and evacuation.

## Evacuation planning

- Can build similar models of human movement.



- Application in building design.

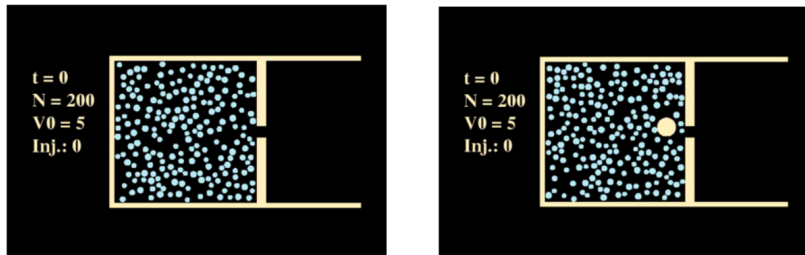
## Evacuation planning



- Application in stadium design.



## Evacuation planning



## Traffic simulation

- Road traffic: ABS allows for understanding congestion phenomena and how changes in infrastructure can impact them (TRANSIMS: TRansportation ANalysis SIMulation System)



<https://www.youtube.com/watch?v=uL5mFuQv-bc>

## Traffic simulation

- Theme park traffic: decreasing waiting times for attractions and optimization of personnel time
- Supermarket traffic: planning suitable routes for customers striking a balance between shortest routes (customers' interest) and longest routes (supermarket's interest)

## Markets

- NASDAQ (National Association of Security Dealers Automated Quotation) has applied in the late 90s ABM to study the impact of a change in their trading rule (reduction of tick size of the market)
- The simulation (by Bios Group, a spin-off of the Santa Fe Institute) used several AI techniques to model agents decision-making
- It showed that the reduction in tick size would increase the bid-ask spread instead of reducing it as expected
- Many current projects now attempt applications of ABS to the understanding of the 2008 financial crisis

- Epidemics depend critically on the network of interactions between agents.
- SIR models (susceptible, infected, recovered) model how diseases spread in a network of agents which move from a susceptible state, to an infected, to a recovered one.
- Transitions between states are described by parameters like probability of infection by contact with an infected agent and the like.  
<https://www.youtube.com/watch?v=G3ynf-aJ4-s>

- When interactions between agents are complex and discontinuous (e.g., market models)
- When space is an important variable and agents' positions vary across time (e.g., evacuation models)
- When the population consists of heterogeneous agents (e.g., epidemic models)
- When the topology of interactions between agents is complex (e.g., epidemic models)

- Today we looked at applications of agents.
- In many of these applications
  - HFT and other bidding agents,
  - Interface agentsthe “agentness” is under the hood.
  - Not clear that the systems involve agents.
- As with most technologies, this integration is a measure of the success of the technology.