Cognitive Agents for Serious Games

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Motivation
Is this AI?

• Idle Behaviours
• Patrol Formations and Tactics
• Reinforcements
• Taking Cover
• Kill Reactions
What is game AI?

• Tasks
  • Pathfinding
  • Bot behavior (chasing, guarding...)
  • Reputation
  • Strategic reasoning
  • Group behavior
  • Learning
  • Etc.

• Techniques
  • A*
  • Rule systems
  • Neural networks
  • Artificial evolution
  • Planning
  • Finite state machines
  • Blobs of random code
  • Etc.
The **illusion** of Human Behaviour

- Game AI is about the illusion of human behaviour
  - Smart, to a certain extent
  - Unpredictable but rational decisions
  - Emotional influences
  - Body language to communicate emotions
  - Being integrated in the environment
- Due to the increasing realism of game worlds, evoking the illusion becomes harder every day
Game AI lies in perception.

Players' goals, beliefs, and emotions are integral to understanding game AI.
Game AI: programming for interpretation

Player → Game → Designer/programmer

Player's Goals, Beliefs, Emotions

Game's Goals, Beliefs, Emotions

Designer/programmer's Goals, Beliefs, Emotions
Behavior = AI + physics (Mind+Body)
AI Tech Situation

• As fidelity of worlds grows, challenge of “just keeping up” ratchets up
  • Pathfinding
    • On a 2d tilemap with 90 degree walls easy
    • On an arbitrary polygon mesh, not as easy
  • Combat posture
    • switching between idle and combat sprites easy
    • managing 100+ bone model, not as easy

• Just keeping old features working is hard
Hand-crafting limits interaction and gameplay
Agents for games

1. Goal directed
   • Agents find ways to reach a goal rather than execute a fixed procedure
   • In case of failure of a plan they can replan

2. Reactive behavior
   • Agents react to events in their environment (while keeping their goal in mind)

3. Social abilities
   • Agents know how to communicate in an abstract and flexible way (ACL is based on speech act theory)
AI and Agent technology

- Separate **operational** and **tactical/strategical** level rules
- Use of models of intelligence. E.g.

- **Learn and adapt parts** of behavior without explicit programming
Agent technology and game engines

Game Engine
- Simulation Engine
- Game State
- Services

Multiagent System
- MAS Engine
- Cognitive Agent
- Sensors

Virtual Environment
- Services
- Game State
- Services

Virtual Agent Body
- Virtual Character
- Actuators
- Sensors
- State

Virtual Agent Mind
- Cognitive Agent
- Sensors
- State

Distributed simulation

Physical simulation

IVA

Cognitive simulation
Bridging the representational gap

• Mismatch between representations of the physical world in the game engine and the cognitive world in the MAS

• Perception
  • Low-level environment information to high-level (symbolic) percepts
  • E.g. ‘a person sitting in a chair’ or ‘a door is open’

• Action
  • Agent actions to character control instructions
  • E.g. ‘pick up a chair’ or ‘open door’
Mind-body abstraction level

- Balancing control
  - Delegation of behavior and inference control
  - Trade-offs: certain efficiency (by game engine) versus autonomy (by MAS)
From agent to human-like IVA

• Relating to software agents in an agent platform
  • Agents become *embodied*
  • Agents become *situated* in a *real-time, virtual* environment
  • Agents require to behave in a *human-like* manner

• Leads to a range of design issues in the areas of
  • Perception
  • Behavior planning and realization
  • Communication
Perception: Multi-modal sensing

- Sensing constrained by human-like sensors like vision, hearing or touch
  - Situatedness
    - e.g. ‘no visibility when out of range’ or ‘no feeling without contact’
  - Sensory capabilities: permanent or dynamic characteristics
    - e.g. eyesight, sun-blindness, frequency range, temporary loss of hearing
  - Environment physics
    - e.g. no sight of objects behind a wall or through thick fog
Perception: Real-time continuous sensing

- Perception of heavily populated and complex environments
- Hundreds of objects, dozens of properties, many times per second
- Risk of cognitive overload and the need for filtering
Perception: Perceiving

• From sensory information to percepts to beliefs
• Combining, interpretation, inferences
  • Changes over time
    • ‘something is moving’ or ‘a sound is fading’
  • Point of view
    • ‘someone is moving towards you’ or ‘someone is talking to you’
  • Semantics
    • ‘a person is running’, ‘a friend is greeting me’
  • Clarity and uncertainty
    • ‘loudness of a sound’, ‘clarity of a visual observation’
  • Observation persistency
    • ‘entering or leaving visual or hearing range’ or ‘a sound starts and ceases to exist’
  • Sensory capability awareness
    • I’ll walk slowly because I can only see several meters in front of me
Behavior planning and realization

• Multi-modal behavior planning
  • Multimodality
  • Parallelism
    • e.g. walking, talking, checking mobile phone
  • Timing
    • smooth transitions between consecutive actions
  • Limited resources
    • e.g. one cannot pick up object when hands are occupied

• Real-time continuous behavior realization
  • Actions take time, result not immediately known
  • Actions may fail because of state change in environment
  • Actions may be aborted because of state change of the agent
Communication: through embodiment

- Expression and perception of multi-modal communicative behavior
  - speech, facial expressions, gazing, gestures, postures, etc

- Separating *what* to communicate from *how* to communicate it
  - E.g. a greeting by waving

- Interpretation: assign meaning to observed behavior
  - E.g. head nod as acknowledgement or form of greeting

- Influence of context during planning and interpretation
  - Self (e.g. personality),
  - Others (e.g. talking to a child)
  - Situational context (e.g. formal versus informal)
Communication: through virtual environment

- **Interruption by external event**
- **Out of range**
- **Partial observation**
- **Overhearing**
A middleware approach: CIGA

- A middleware to couple MASs with game engines
  - Facilitate designers in coping with the design issues
  - Two levels: infrastructure + conceptual
CIGA technical level: Infrastructural facilitations

- Inter-process communication
  - Asynchronous communication for acting and sensing
  - Offers connection transparency between MAS and game engine

- Time management
  - Synchronization of real-time controlled by the physical simulation
  - Offers agents awareness of the notion of time

- IVA life-time management
  - Synchronization of the life-time and physical/social profiles of IVAs

- IVA context management
  - Synchronization of an IVA’s dynamic state
  - Cognitive factors may influence physical processing and vice-versa

- Ontology service
  - Interface design contract based on ontologies
  - Designer-modeled syntax and semantics for a sense-act interface
CIGA conceptual level: IVA design facilitations

• Semantic virtual environment
  • Facilitates perception at a strategic level of abstraction

• Subscription-based filtering mechanism
  • Facilitates top-down cognitive control over perception

• Coordination management
  • Facilitates realization of inter-IVA coordinated activities

• Physical and social activity management
  • Facilitates action and intent recognition
  • Facilitates communication
Evaluation: CIGA platform and couplings

- Coupling with multiple game engines and MASs
Evaluation: Use case scenario

- Rational decision-making
  - strategic perception, planning, action-failure, perceptual attention
Evaluation: Student project

• 9 students, 20 weeks
• Connection with new game engine (Unity3D) and MAS (custom)
Conclusion

• A middleware approach was found fruitful
  • Technical support: new connections could easily be established
  • Interface design support: easily adaptable user-modeled sense-act interface through ontologies
  • IVA support: efficient perception, coordination and communication through centralized data management approach

• Future design challenges:
  • Focus on IVA architectures: inter-connection of conceptual components
Adapt the game to the user

A user only learns if performing on his own level

Beginner: Frank

Expert: Joost
Datamining of gameplay logfiles gives information about players

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<th>Component Variable**</th>
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Table 4: Final Factor Definitions of the PA Model (BF3)

Speed, Performance, Preference and Play time predict players age (12-65)
Current approaches

- Fixed difficulties
- Central control or no coordination
- Mainly adjust simple subtasks
Dynamic Difficulty Adjustment

• Online adaptation:
  Continuously balance challenges in the game with (developing) skills of the trainee
Aspects

• User
  • Evolving skills (when learning)

• Characters
  • Characters adapt independently
  • Characters active for long periods, so, adaptation should be believable

• Keep storyline
  • Learning goals have to be maintained!

• Adaptation must be coordinated!

• Performance can not be measured separately for each skill and influence of each agent
Adapt the game to the user

Use agents to have characters adapt natural and independent
Adapt the game to the user

Use agents to have characters adapt natural and independent
Adapt the game to the user

Use an agent organization approach to ensure the goals of the overall system.
Story-line

- Guarantee certain states are reached
- Subtasks defined by scene scripts and landmarks
- Connected by interaction structure
  - Describes game progress
  - Connecting scenes
  - Tasks in parallel

Start ➔ Get to site ➔ Gather info ➔ Search building ➔ Evacuate victims ➔ Secure area ➔ Extinguish fire ➔ Clear area ➔ End
Agent Implementation

- Adaptable BDI-agents (2APL extension)
  - Equivalent plans
  - Preference relation
  - Environmental information also used

Search building

- Pairwise search
- Parallel search
- Thorough search

Evacuate victims

- One by one
- Groupwise

floors
rooms
Front/back
Floors parallel
Rooms parallel
Front/back parallel
Living quarter first
Utility rooms first
Top floor first
Adaptation Engine

- Coordinates task difficulty
- Check with game model
- Combinatorial auction
  - User model
  - Agent preferences

2APL Agent

Agent Bidding

User Model

Game Model

Preferences & Termination

Applicable plans

Scene States

Plans Bid

Selection

Task Weights

Skill Levels

Update

Start → Get to site → Gather info → Search building → Extinguish fire → Clear area → End

Secure area → Evacuate victims

Scene States

Applicable plans

Preferences & Termination

Selection

Task Weights

Skill Levels

Update
Task Difficulty

• Task dependent on behavior of the agents
• Behavior variations are fixed
• Estimated by domain expert
• Updated by offline learning
• Much faster adaptation
Agent Perspective

• Agents Propose actions to adaptation engine at “natural” synchronization points
• Created to facilitate trainee’s objectives (optimize agent behavior relative to trainee’s performance!)
• Not responsible for suitable combination
• Conflict:
  • Stay as consistent as possible
  • Propose enough actions
• Adaptation engine can request agents to terminate behavior if necessary for coordination
Conclusion

- Continuous adaptation to the trainee
- Agent based approach
  - Complex individual behavior and adaptation possible
- Agent organisation for coordination
  - Balance between individual flexibility and global story line maintaining learning goals
  - Constrain based only on global landmarks and learning goals
  - Minimal central control for more efficiency and more flexibility