Goal-based Communication for BDI Agents as Virtual Humans in Training:

An Ontology Driven Dialogue System

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Overview

- Research Goal
- Virtual Human Design
- Ontology
- Goal-based Dialogue System
- Human-in-the-loop
- Conclusion
- What’s next
Research Goal

- Goal: Create conversational cognitive agents for training
- Use Case: Fire Incident Management Training for Navy
- Training command & control competencies for a commanding officer
  - Decision-making
  - Situation Awareness
  - Procedures
  - Communication
- Communication essential
- Augment BDI agents with communicative abilities
Research Questions

- How can BDI goals be used for communication?
  - Information exchange, motivation exchange
- How to coordinate goals and actions related to communication with other activities?
- How to ensure a natural flow of communication to achieve human-like simulated interactions?
- How to integrate non-agents? (the trainee)
Virtual Human Design

- Interface at level of ‘intentions’ and beliefs
  - Intentions: communicate, moveto, answerphone
  - Beliefs: worldbeliefs, intentionbeliefs, communicationbeliefs
- Plan execution synchronized with the game engine
Ontology

- Domain concepts shared by agents and distributed components
- Create an ontology to manage concepts

Functions:
- Limits the concepts agents reason about, goals they adopt and action they’re able to perform.
- Describes the environment in the game engine
- Defines interface between MAS and game engine
- Used in communication language as semantics

- Ontology for concepts, goals and actions
Ontology Example

- Ontology used everywhere: many dependencies
- Requires thorough design to avoid future changes

Dialogue

Officer 1: A fire is discovered in the laundry room!
Officer 2: Understood. What type of fire?
Officer 1: It is an oil fire.
Officer 2: Ok. Attack the fire using foam!
Officer 1: Understood.

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Officer 1: The fire in the laundry room has been extinguished.
Officer 2: Understood. The fire in the laundry room is extinguished.
Goal-based Dialogue System

- Agents sharing ontology can use simple dialogues to communicate automatically
  - Communicate knowledge
  - Communicate motivations

- Give BDI agents communicative abilities where ontology defines possible communication content

- Ontology-driven goal-based dialogue system
  - Communicate semantic content: *Communication goals*
  - Provide a natural flow of conversation: *Conversation goals*
Communication Goal (1)

- Communication goal: a single ontology-driven dialogue between two agents.

- Communication Goal
  - Dialogue type
  - Protocol

- Two roles:
  - Initiator: Desires to achieve the goal
  - Participant: Collaborates initiator to achieve his goal
Communication Goal (2)

Communication Goal Initiator

- Follow protocol
- Compare result with desired result

Protocol Dialogue Type

- Communicative Acts

Communication Goal Participant

- Follow protocol
Three types of goals with a one-turn protocol

<table>
<thead>
<tr>
<th>Goal Type</th>
<th>Response Act</th>
<th>Dialogue Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inform(belief)</td>
<td>agree(x)</td>
<td>belief added to the participant's belief base</td>
</tr>
<tr>
<td></td>
<td>disagree(x)</td>
<td>-</td>
</tr>
<tr>
<td>Question(belief)</td>
<td>belief(x)</td>
<td>belief added to the initiator's belief base</td>
</tr>
<tr>
<td></td>
<td>unknown(x)</td>
<td>-</td>
</tr>
<tr>
<td>Order(goal)</td>
<td>accept(x)</td>
<td>goal added to the participant's goal base</td>
</tr>
<tr>
<td></td>
<td>reject(x)</td>
<td>-</td>
</tr>
</tbody>
</table>
Communication Goal (4)

Advantages
- Communication goals give BDI agents additional means to achieve their desires
  - Satisfy preconditions of other goals
  - Delegate goals
- Communication goals can be treated similar to other goals
  - Prioritization depending on speech partners or topics

Agents can have multiple communication goals active
- Problematic for simulating human-like communication
- Need for a higher-level control → conversation goal
Conversation Goal (1)

- Manages execution one or more communication goals with one participant
- Ensures attention between two speech partner
- Commencing and termination rules ensure valid channel
- Automatically adopted and dropped: Agents don’t actively have to concern themselves with performing believable communication
Conversation Goal (2)

- Automatically adopted when:
  - Agent has one or more comm. goals to achieve
  - Agent has received communication request

- Automatically dropped when:
  - No more comm. goal active with participant
  - Termination act received from participant. Active goals with this participant will fail and cannot be achieved anymore within this interaction instance
  - Agent has higher priority tasks to achieve
Conversation Goal (3)

- Interaction Phases
  - Commencing phase
  - Active-conversation phase
  - Terminating phase

- During conversation, agents can still react to collaboration requests
  - Accept and terminate current to start new conversation goal
  - Reject verbally or nonverbally

- Agent can reason about priorities of communication goals which can result in attention shift
Communicative Action & Perception

- Agents in MAS can communicate directly: not an option for agents simulating virtual humans
- Communication action: use same channels as humans would (verbal/nonverbal communication)
- Communication Perception: bounded by simulated laws of physics
- Dialogue act: parameterized action
  - Intended target
  - Performative
  - Semantic content according to ontology
Human-in-the-loop

- For training, human needs to use the dialogue system
- Difference: BDI agents control avatar from the MAS, the trainee uses input devices processed in game engine
- Consequence: Communication acts have to be available in the game engine
  - Ontology accessible from game engine to create/validate acts
  - Acts dynamically determined from the MAS
- Communication Interface
  - Dialogue interface
  - Speech input
Dialogue Interface
Conclusion

- Main Goal: augment BDI agents with human-like communicative abilities so they can perform practical dialogues helping them to achieve their desires.

- Introduced an ontology-driven goal-based dialogue system simulating natural human-like interactions
  - Communication goal: for achieving a communicative purpose
  - Conversation goal: for managing interactions in a believable way

- Applicability
  - Agent-based simulation training command & control
    - Closed domain, protocols, formal communication
What’s next?

- Rules and norms for agents about communication
- Decision to use communication very complex
  - Agent’s identity/role
  - Current situation
  - Available alternatives
- How to handle communication failure?
- Theses rules and norms should be easily accessible for designer.

Dialogue System Extensions:
- More goal types (e.g. negotiation, resolve-of-conflict)
- Composite commands goals for more complex dialogues
- Standard protocols (FIPA)
System in action

[movie1] [movie2]
The End

Thank you for listening

Questions?