Believable NPCs in Serious Games: HTN Planning Approach Based on Visual Perception

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Overview

• Motivation
• Believable NPCs
• Visual Perception in Virtual Environments
• Strategic Planning Using HTN
• Our Approach
• Experiment: Car accident scenario
• Conclusion and Future Work
Motivation

• Serious games are designed to provide a learning platform for intended players and were successfully applied in industries like emergency management, health care, etc.

• Serious games are used as a learning platform will reduce costs, efforts and time spent in real-world training.

• Cooperations and interactions in serious games play critical roles in training, e.g. cooperations among firefighters, interactions among patients and doctors, etc.

• Believable non-player characters (NPCs) provide more realistic game experience and training environment for serious games.

• Players can behave, react, interact and study with designed believable NPCs while playing and training.
Believable NPCs

- Sense the environment: Visual perception, hear and smell
- Collect information: Memorize critical objects according to the environment (Short-term memory)
- Domain knowledge (Long-term memory)
  - Professional skills
  - Methods or action sequences to solve tasks
- Problem solving (Strategic plans)
  - Generating plans to solve goal tasks
- Act: animate and interact with the environment as well as the player properly

![Diagram of NPC functionalities]
Visual Perception in Virtual Environments

- Sensing the world like a human
  - Limited view angle and distance
  - (Partial) Occluded objects
  - Light interference
  - Center of attention
  - Objects size and distance
Visual Perception in Virtual Environments

- Camara mimics human eye using multi-levels (1 to n) of concave retinas
- Squares and ray casting
- NPC "sees" an object when the ray hit the object with the closest retina
- NPC cannot "see" an object when the ray hit the view distance
- The more squares of retina hit by the object, the less the probability will be to miss.
- Each NPC has its own list of "seen" objects list
Visual Perception in Virtual Environments

- Angle and distance test
- Difference size
- „Seen“ objects

**TABLE I.  PERCENTAGE OF SEEN OBJECTS**

<table>
<thead>
<tr>
<th>Size, Location</th>
<th>Number</th>
<th>[0 - 60]</th>
<th>[60 - 90]</th>
<th>[90 - 130]</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>big, far</td>
<td>30</td>
<td>90%</td>
<td>90%</td>
<td>83%</td>
<td>87.6%</td>
</tr>
<tr>
<td>big, close</td>
<td>30</td>
<td>100%</td>
<td>100%</td>
<td>93.3%</td>
<td>97.7%</td>
</tr>
<tr>
<td>small, far</td>
<td>50</td>
<td>82%</td>
<td>78%</td>
<td>42%</td>
<td>67.3</td>
</tr>
<tr>
<td>small, close</td>
<td>50</td>
<td>96%</td>
<td>86%</td>
<td>66%</td>
<td>82.6%</td>
</tr>
</tbody>
</table>
Hierarchical task network (HTN)

- Tasks in serious games, e.g. firefighting, have a built-in hierarchical structure.
- HTN could help construct plans from the built-in hierarchies.
Method decomposition in HTN planner

Method: Extinguisher-fighting(fire)
- Goto-FireExtinguisher
- PickUp-FireExtinguisher
  - Goto-Fire
    - Fighting(fire)
Method decomposition in HTN planner
Method decomposition in HTN planner:

Method: Extinguisher-fighting(fire)

- Goto-FireExtinguisher
- PickUp-FireExtinguisher
- Goto-Fire
- Fighting(fire)
Our Approach

- World Model
  - Long-term Memory
  - Short-term Memory
- State Manager
- Interface
- Vision Perception
  - Primitive Actions
  - Controller
- Game World Environment
  - Task Trigger
  - Physical Body (animations)
- Planner
  - HTN
  - Seek Plan
- Domain
Our Approach - Vision perception

- Vision Perception
  - Sense the task related objects
  - Task Trigger
  - Physical Body (animations)

- World Model
- Long-term Memory
- Short-term Memory
- State Manager
- Interface
- Game World Environment
- Planner
  - Seek Plan
  - Domain
  - HTN

- Controller
  - Primitive Actions
  - Task Trigger
  - Physical Body (animations)
Our Approach - Short-term memory

- World Model
  - Long-term Memory
  - Short-term Memory
  - Vision Perception

- State Manager
  - Primitive Actions

- Planner
  - Domain
  - HTN

- Controller
  - Task Trigger

- Physical Body (animations)

- Game World Environment

Store the information
E.g. Car:
- Car_location (Transform)
- Is_on_fire (Boolean)
- Number_of_people_inside (Integer)
Our Approach - Long-term memory

- World Model
- State Manager
- Long-term Memory
- Vision Perception
- Primitive Actions
- Controller
- Game World Environment
- Task Trigger
- Physical Body (animations)
- Planner
- Domain
- HTN

Initialize the main task the NPC will have to solve: e.g. HandleCarsAccident
Our Approach - Understanding the virtual environment

- **World Model**
  - Information from memory represented in a way NPCs will understand

- **State Manager**
  - Update states

- **Planner**
  - Seek Plan
  - HTN

- **Domain**
  - Seek Plan

- **Controller**
  - Primitive Actions

- **Vision Perception**

- **Game World Environment**
  - Task Trigger
  - Physical Body (animations)
Our Approach - Bridging

World Model

Long-term Memory

Short-term Memory

Vision Perception

Primitive Actions

Game World Environment

Task Trigger

Physical Body (animations)

State Manager

Interface

Bridging the world model, planner and controller

Planner

Domain

Seek Plan

HTN
Our Approach - Action sequences generated via HTN-planner

- Planner will generate an action sequence to fulfill the goal tasks
Our Approach - Real actions

Controller contains real actions which control the NPCs in the game and plays the appropriate animations.
Experiment: Car accident scenario

- KATIE
- Unity
- City: Burgstadt
- Accident scene
- Car crash in front
- Fire starts in one of the car
- Two heavily injured and
- the rest slightly
- Firefighters arrive after the accident
Experiment: Car accident scenario

• Firefighter
• Navigation and (visual perception) collect information to their short-term memory
• Understand the world by developing their world-model

• Accident car has been „seen“ triggers HandleCarsAccident
• A plan will be generated from the knowledge (long-term memory)
• NPCs behaves as the real firefighters

1. <HandleCarsAccident>
2. <RescueHeavilyInjuredPerson>
3. <FightFire>
4. {PickUpFireExtinguisher}
5. {GoToFireLocation}
6. {UseFireExtinguisherToFightFire}
7. {DropFireExtinguisher}
8. <ExtractInjuredPersonFromCar>
9. <OpenCarDoor>
10. {PickUpSpecialTool}
11. {GoToCarDoor}
12. {UseSpecialToolToOpenDoor}
13. {PullInjuredPersonOutOfCar}
14. {ApplyFirstAidToInjuredPerson}
15. <MoveInjuredPersonToAmbulance>
16. {BringStretcherNearInjuredPerson}
17. {CarryInjuredPersonToStricker}
18. {MoveStretcherToAmbulance}
Conclusion and Future Work

• Visual perception
  further factors which influence the visual, e.g. light, weather
  other perception, e.g. smell, hear, sense of temperature, etc.

• HTN
  domain extension
  scene with dynamic events and runtime planning