

1

A User-Controlled Approach to Adjustable Autonomy

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2

Outline

- Autonomous agents
- Adjustable autonomy
- Pilots for Saab's TACSI simulator
- EASE (End-user Actor Specification Environment)
- Examples and discussion
- Summary

3

What is an Autonomous Agent?

Interacts with its **environment**

1. can **sense** its environment
2. make **decisions**, and
3. take **action**

percepts
Sensors: eyes, sonar, ...
environment
agent
actions
Effectors: hands, motors, ...

4

What is Autonomy?

The breadth of goals that an agent has the authority to accomplish and the latitude it has to achieve those goals (Barber et al.)

Command driven
Local autonomy/master
Consensus
Decision-making styles and autonomy

5

What is Adjustable Autonomy?

- When agents (human and/or software/hardware) in a system **dynamically** change the allocation of authority and latitude for achieving goals among themselves.

6

Why Have Adjustable Autonomy?

- Essential - enables the use of systems where otherwise impossible/difficult
 - sensor deficiencies, unusual events, cost/time, complexity, unanticipated situations, personal preferences, physical limitations, moral questions,
- Useful - faster/easier development
 - incremental development, faster testing, debugging, users have control via interfaces
- Result – powerful and flexible systems

7

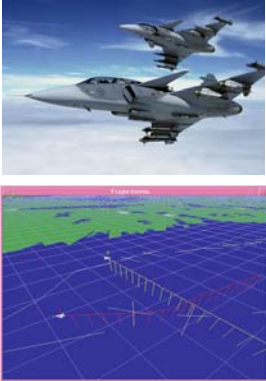
Application: Simulation Environments

- Highly complex, real-time training and testing simulation environments
- Autonomous agents used in place of humans or other entities
- Examples
 - Pilots for aircraft
 - Agents for soccer
 - Agents for disaster management

8

Simulated Pilots in TACSI

- TACSI, Saab AB
 - commercial simulation environment
 - JAS Gripen - 4th gen. fighter aircraft + other AC
 - Full cockpit/dome interface
 - Steering control interface
- Simulated pilots
 - During aircraft design, development and testing
 - During pilot training and interactive simulations to reduce load on instructors



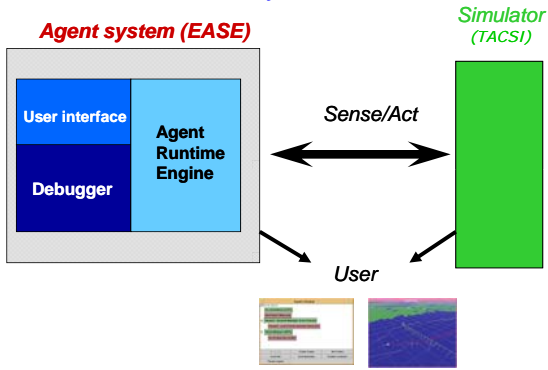
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EASE (End-user Actor Specification Environment)

- Software to specify multi-agent actors in simulation environments
- Graphical development tools
 - Graphical actor design and behavior specification
 - Define goals, calculations, constants needed
- Runtime engine/debugger
 - Visualize actor behavior and multi-agent system
 - Monitor internal structures
 - On-line modifications to actor
 - Supports adjustable autonomy
- Designed and implemented at Linköping University

10

EASE/TACSI System Overview



11

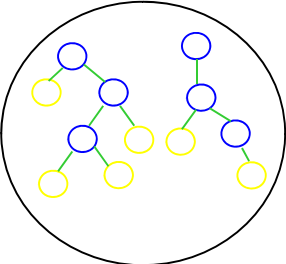
EASE Agent Hierarchy

Agents =goals/subgoals”

Manager agents – non-leaf nodes

Contracts - connections between goals and subgoals

Engineer agents - (leaf nodes) negotiate over the actions (output) of the actor

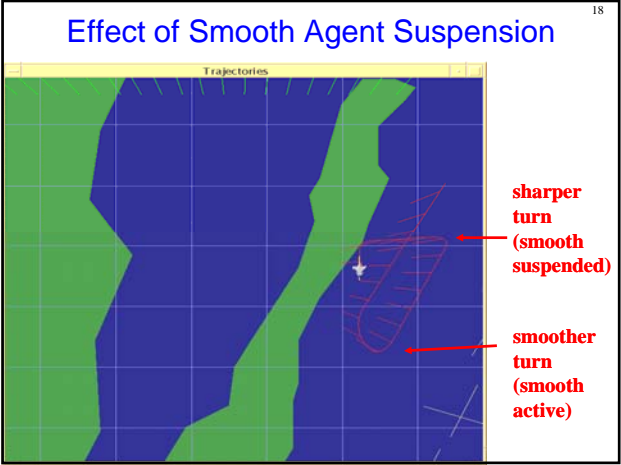
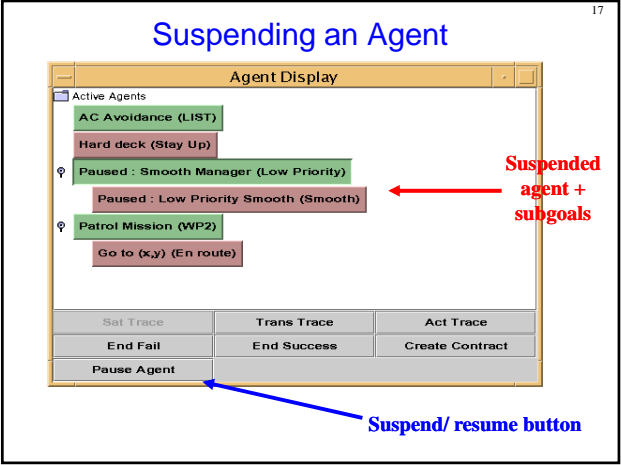
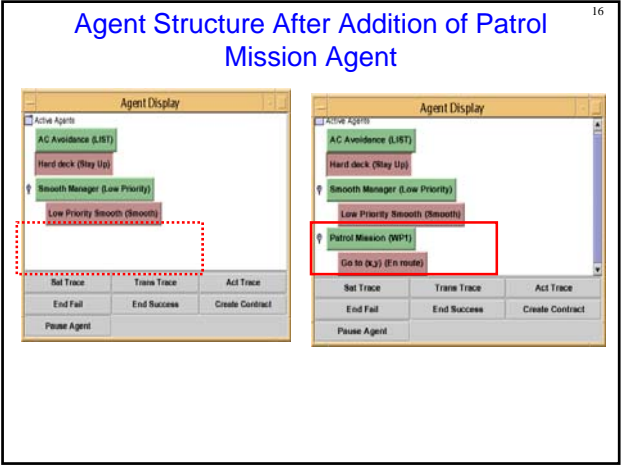
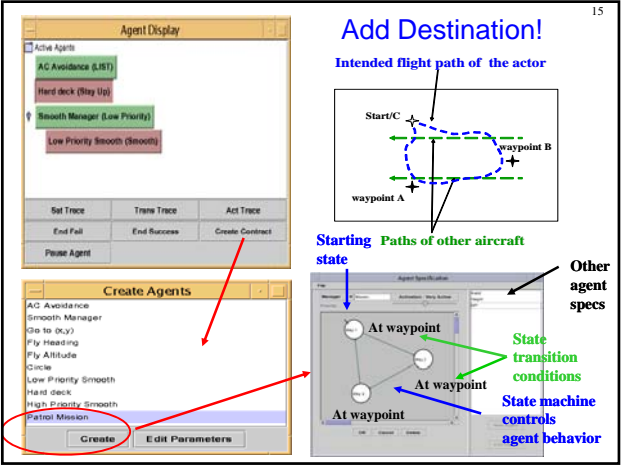
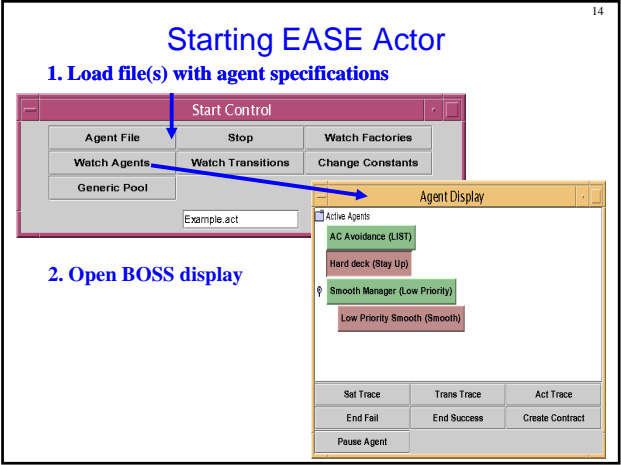
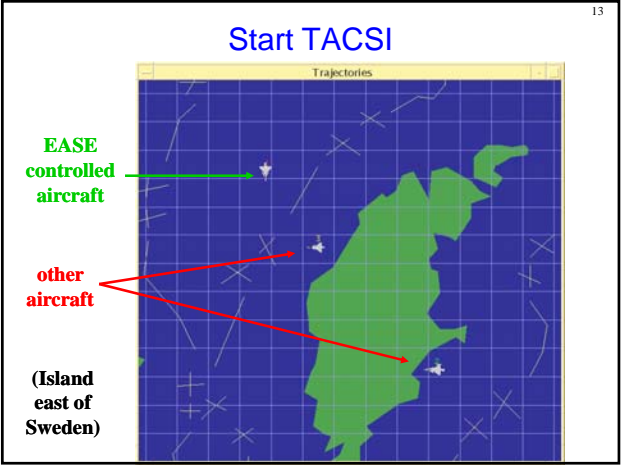


EASE actor

12

Example of Adjustable Autonomy

- 1 EASE controlled aircraft
- 2 “hostile” aircraft
- 3 initial goals
 1. **Avoid** - avoid other aircraft - one agent will be created for each aircraft detected
 2. **Hard deck** - do not hit the ground
 3. **Smooth** - make turns smoothly
 - limited by aircraft controller and pilot tolerances
- User monitors and modifies behavior of Pilot
 - Add, Delete, or Suspend a goal
 - Edit specifications



User Termination of Agent

- User chooses how agent reports:
 - end success or
 - end fail
- Agent and all its children are terminated
- Success/fail sent to contractor agent
- State transition in contractor agent according to specification (success/fail)
- Example - end waypoint agent

20

Development/Runtime Tools

21

Agent Behavior Specification – Actions and Functions

22

Discussion

- Powerful adjustable autonomy capabilities
- EASE is a prototype
 - Interfaces need improvement
 - User must learn EASE and design actor behaviors
 - Factors not explicitly encoded in EASE’s agent hierarchy or state machines are difficult to modify
 - Real-time response of environment may limit user’s control of actor (hard- or soft- real time)
- Other types of adjustable autonomy
 - Agent initiated only or both

23

Summary

- Adjustable Autonomy – useful or necessary
 - Increase the usability of agent systems
 - Increase agent development productivity
 - Allow use in complex environments
- EASE - GUI development environment
 - Specification of behavior
 - Add, modify, and delete actors’ behavior specifications/ state machines
 - Monitoring/debugging capabilities – runtime engine
 - Observe goals and behavior of actor on-line
 - Observe calculations determining behavior
 - Adjustable autonomy capabilities
 - Add, suspend, and delete goals (agents comprising actor)
 - Add, modify or delete constants
 - Modify behavior specifications

24

25

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26

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