Lecture 11:

How, Why and When to use AuRAs (Augmented Reality Agents) 2014

COMP 30025J

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Abstract

- Over the last number of years, multiple research projects have begun to create Augmented Reality (AR) applications that use Augmented Reality Agents, or AuRAs, as their principle interaction and development paradigm. In this new research area, *how*, *why*, and *when* to use AuRAs are naturally the first open questions and the ones this paper aims to begin to answer.

Conclusions

- *How* Augmented Reality Agents can be developed: Using the AFAR toolkit, which is *ready to go* and fully integrated with a back-end agent-based development environment
- *Why* developers should use AuRAs: The evaluation of a simulated AR experiment demonstrated the advantages of using AuRAs demonstrates how a CAVE-like simulated AR environment can be used and it shows how the AuRAs can increase the performance of a user
- *When* AuRAs should be used to develop AR application Given a list of guidelines for the developer to follow

Introduction

- Presents a Distinct field of *Augmented Reality Agents*
- *How* AuRAs can be developed using AFAR plugin
- *Why* AuRAs constitute a useful concept in AR applications though experiments
- *When* it is appropriate for a project to use AuRAs, and when their addition would simply add unnecessary complexity

2 Defining AuRA's & 2.1 Definition of Agent

- An *agent* can be defined as "a computational entity that must sense, deliberate and then act".
- Wooldridge & Jennings's (1994) Weak notions included
  - Autonomy, Social ability, reactivity and proactivity
- Wooldridge & Jennings's (1994) Strong notions included
  - Mobility, Veracity, benevolence and rationality
- This ideas build on Shoham work from 1993
  - Knowledge, Belief, intention and obligation
  - Also the concept of Agent Oriented Programming
- Finally Rao and Georgeff (1995) the overall concept of
  - Beliefs, Desires and Intentions (BDI) was introduced

2.2 Definition of Augmented Reality Agent

- "An agent embodied in a Mixed Reality environment" by Holz et al 2011
- *Corporeal presence*
  - Corporal presence is defined by an agent's degree of situatedness within its virtual or physical representation
- *Interactive capacity*
  - An agent's virtual interactive capacity is defined as an agents ability to sense and act within a virtual environment,
  - Its ability to sense and act within the real world defines its physical level of interactive capacity.

3 Related Work & 3.1 Previous Examples of AuRA's

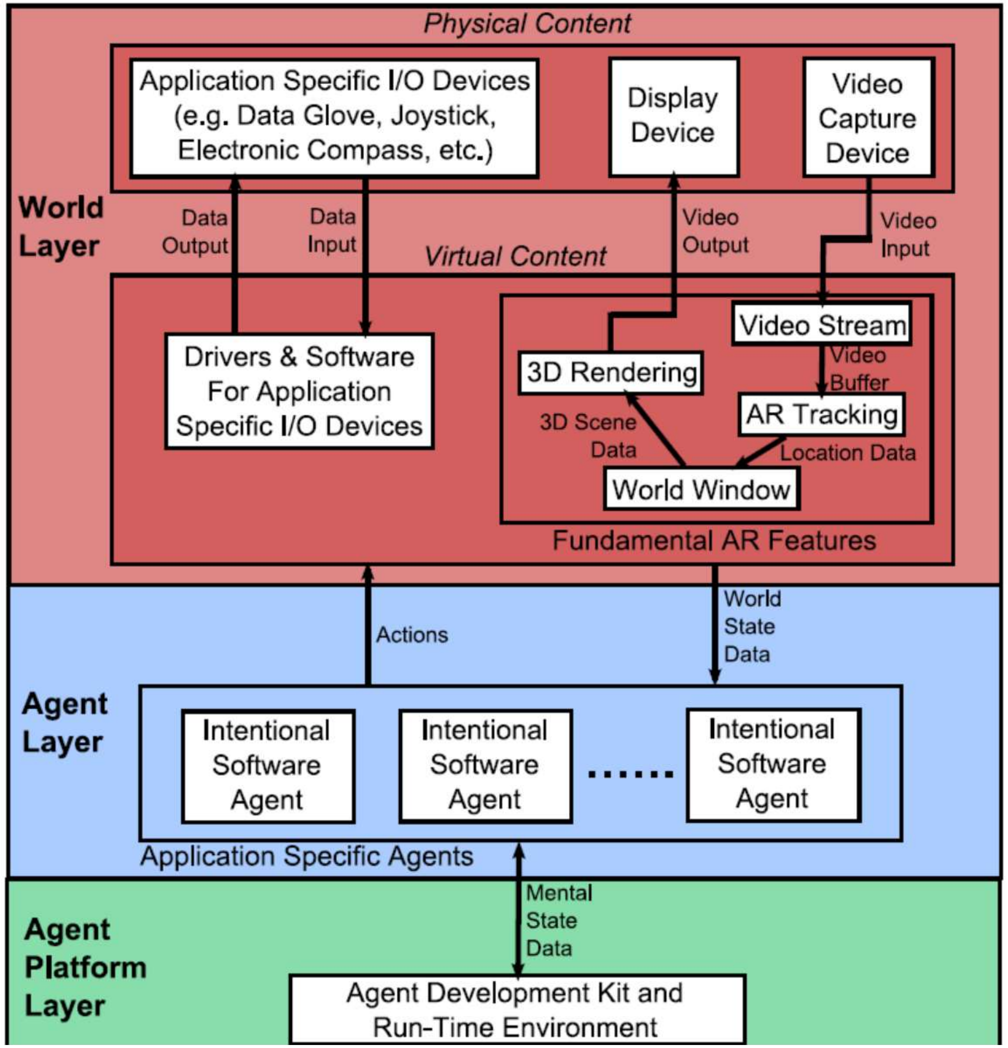
- Previous Work
- O'Hare et al 2004
- AR Puppet & UbiAgents by Barakonyi

3.2 Simulated AR

- The concept of AR simulation, in which human-computer interaction in Virtual Reality is examined and lessons learnt are applied to Augmented Reality, is not a new one. It was first outlined by Dieter Schmalstieg in 2005
- Simulated AR can offer a
  - Complete Field of View (FOV)
  - Precisely locate every object within the environment
  - Registration error is non-existent, unless needed

4 How to Create AuRA's- The AFAR plugin & 4.1 Architecture of AFAR

- Agent Platform Layer Comprising of the tool-set for agent development and the run-time environment on which to deploy said agents.
- Agent Layer Containing the application specific agents, incorporating their pre-defined mental states and tools that enable them to perceive and enact changes in the AR environment.
- World Layer Representing the AR environment itself. This layer is further subdivided into its physical and virtual components to reflect the duality of this technology.

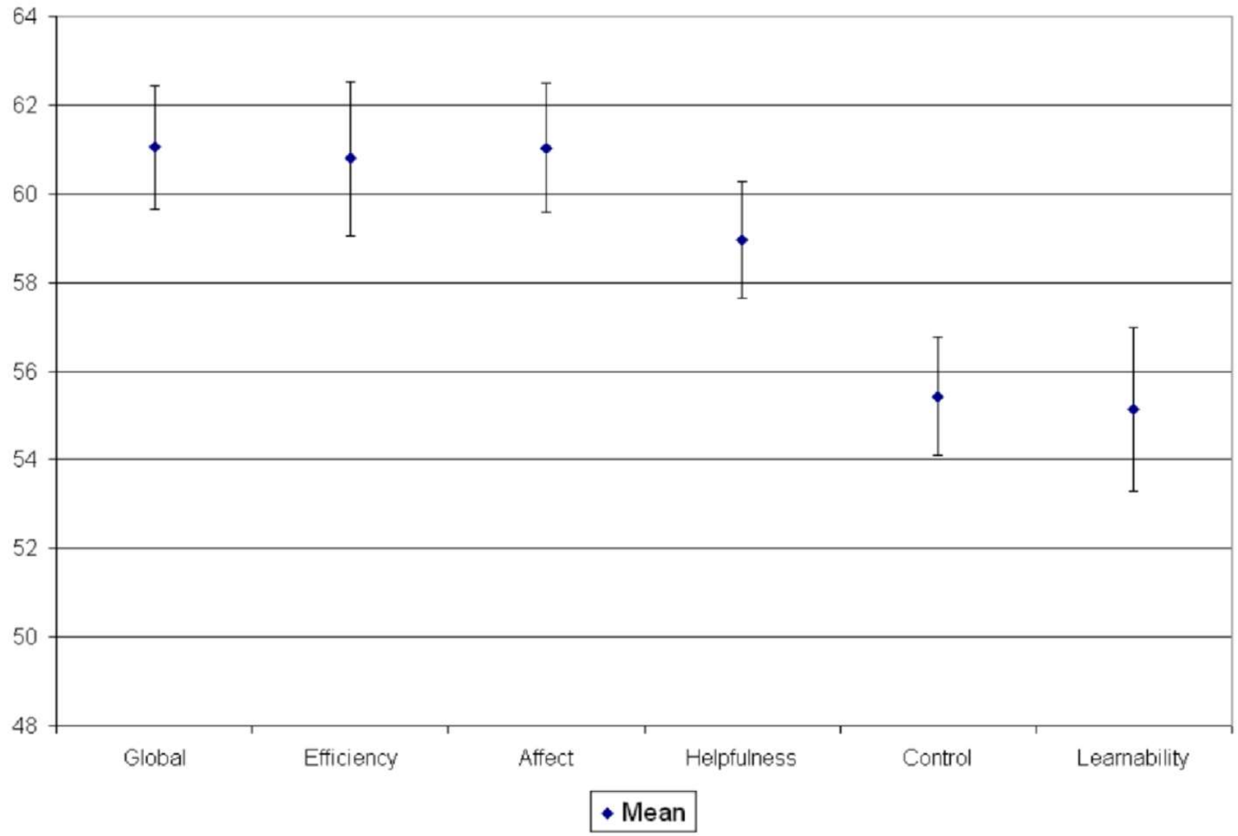


4.2 Implementation of the Toolkit

- Concept broken into two areas for implementation:
- (1) creating the agents, or *ghosts*, behind the AuRAs;
  - AuRAs constructed using AFAR employ the Agent Factory Agent Programming Language version 2 (AFAPL2)
- (2) the virtual models they will be embedded within, the *shells*.
  - The scene graph generated by Java3D is an integral part of AFAR, and the shells are realised as Java3D TransformGroup objects.

4.3 Evaluation of the Toolkit

- 32 individuals tested
- SUMI's Item Consensual Analysis (ICA) is designed to enable the analysis of individual responses and to contrast observed candidate responses to individual items with those that are expected
- Scores over 50 are above control tests.



5 WHY CREATE AURAS — AN EXPERIMENT IN SIMULATED AR

- Layar: A 3D sphere placed in the target location that can be seen through walls aids participants in navigating around the supermarket. This is currently the most widely used AR navigation approach and the one taken by the Layar mobile browser [13] on today's smart phones.
- Arrows: Multiple software agents embedded in the supermarket shelves collaborate with their neighbours to find the shortest route from their position to the target. They then generate directional arrows near themselves to point the way.
- Avatar: A humanoid avatar leads participants, using movement and speech, along the shortest route to the target object, as determined by the same embodied software agents employed in the arrows condition.

5 WHY CREATE AURAS — AN EXPERIMENT IN SIMULATED AR Cont.

- Hypothesis 1. As the agents embedded in the shelves provide an actual shortest route to the target object, participants following the arrows will accomplish the task faster, and travel less distance than those guided by the bubble.
- Hypothesis 2. The avatar, despite providing the same information as the directional arrows, will nonetheless outperform the other two conditions due to its anthropomorphic form. Specifically, participants following the avatar fill accomplish the task faster, and travel less distance, than those following either the arrows or the bubble.

5.1 Experimental Methods & 5.2 Experimental Design

- Two quantitative measures of performance:
  - distance travelled (measured in metres)
  - duration of the task (measured in seconds)
- The questionnaire contains 21 statements, each rated on a 7-point Likert scale, and covers the dimensions of *being there*, *not being here* and *reflective consciousness* (awareness of being there).
- 54 participants (35male, 19 female), aged 18–38 years (*M* = 22*:*17, *SD* = 4*:*237)
- Each group used one of three AR navigational aids (Layar, Arrows, Avatar) to achieve a way-finding task in a simulated supermarket.

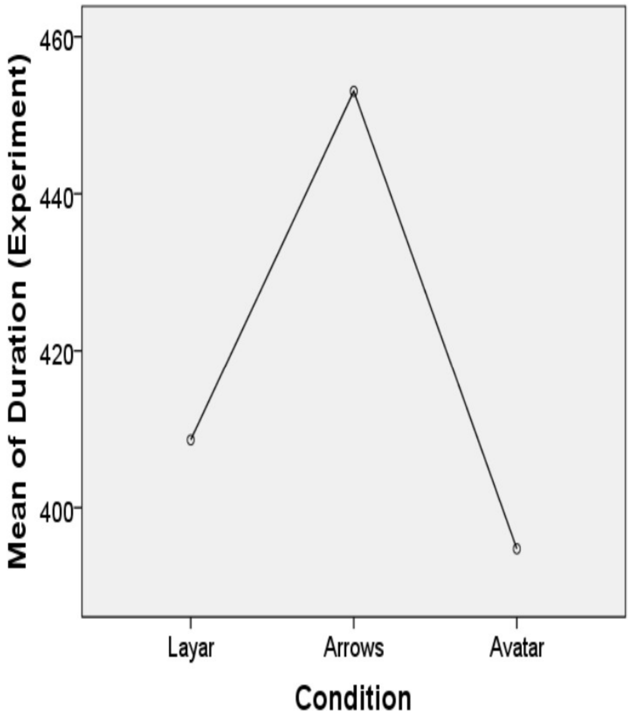
5.3 Physical Setup

- LAIR paper already covered this
- 360 LAIR room used
- Dancepad used for movement

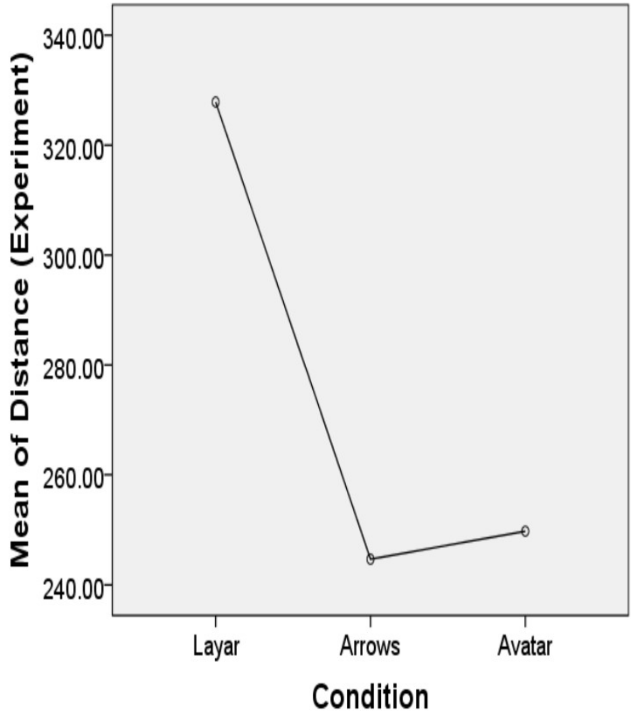
5.4 Protocol

(i) (ii) (iii)

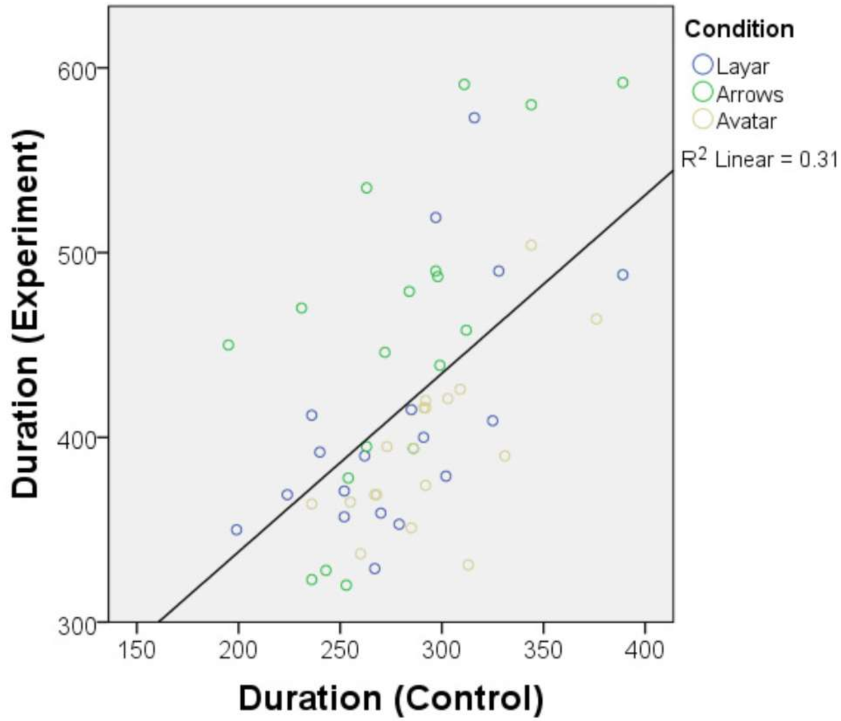
5.5 Results



Mean of Duration (Experiment)
460
440
420
400
Layar
Arrows
Avatar
Condition



Mean of Distance (Experiment)
340.00
320.00
300.00
280.00
260.00
240.00
Layar
Arrows
Avatar
Condition



Condition
Layar
Arrows
Avatar
R^2 Linear = 0.31
Duration (Experiment)
600
500
400
300
150
200
250
300
350
400
Duration (Control)

5.5 Results

- The type of navigational aid had a further significant effect on the distance traveled ($F(2;8) = 27:581$, $p < :001$).
- Post-hoc t-tests found a significant difference between the Layar and Arrows condition ($t(9) = 6:956$, $p < :001$), and between the Layar and Avatar condition ($t(9) = 7:341$, $p < :001$) but not between the Arrows and Avatar condition ($t(9) = -:864$, $p = :410$). This indicates that participants in the Layar condition travelled significantly further than those in either the Arrows or in the Avatar condition.

6 WHEN TO USE AURAS — GUIDELINES FOR AR DEVELOPERS

- Completely versus partially observable environments
  - Any application will therefore have to cope with being able to obtain only partial knowledge about its environment.
- Deterministic versus stochastic environments
  - Unpredictability of the environment leads to ambiguity
- Episodic versus sequential environments
  - Awareness of past states and of the consequences of their actions on future states of the environment

6 WHEN TO USE AURAS — GUIDELINES FOR AR DEVELOPERS cont.

- Static versus dynamic environments
  - AR environment encompasses the real world which is, by its very nature, dynamic
- Discreet versus Continuous environments
  - This challenge manifests itself most plainly in registration errors
- Single- versus multi-agent environments
  - Not only accounting for the User and the AR world but also needing to coordinate with other users (some agents and some real users) to achieve a common goal
- Fundamentally, we need an abstraction that can cope with the emergent behaviour of the system, an agent oriented approach gives us that advantage. When AR applications get too complex, an agent approach could offer a solution to that complexity

Next week

- **"3D printing based on imaging data: Review of medical applications"** by Rengier· A. & Mehndiratta& H. von Tengg-Kobligk & C. M. Zechmann &R. Unterhinninghofen &H.-U. Kauczor&F. L. Giese

AR Reality Questions

- “How can you program a Augmented Reality application ?”
  - Examples
    - Piekarski & Thomas
    - Krevelen & Poelman
    - Campbell et al
    - **Geiger et al**