PROGRAMMING ABSTRACTIONS for AUGMENTED WORLDS

Angelo Croatti, Alessandro Ricci

DISI - University of Bologna - Italy
ABOUT AUGMENTED WORLDS
ABOUT AUGMENTED WORLDS

• Augmented/Mixed Reality
  - merging real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real-time
  - recent technology boost

• Microsoft Hololens, Magic Leap, Google Project Tango, Meta systems, …
ABOUT AUGMENTED WORLDS

• Augmented/Mixed Reality
  - merging real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real-time
  - recent technology boost

• Microsoft Hololens, Magic Leap, Google Project Tango, Meta systems, …
(Microsoft Hololens demo - Project X-ray, October 2015)
(Microsoft Hololens demo - Project X-ray, October 2015)
DIFFERENT FORMS OF AUGMENTATION

• Integrating further forms of augmentation besides AR/MAR
DIFFERENT FORMS OF AUGMENTATION

• Integrating further forms of augmentation besides AR/MAR

• pervasive/ubiquitous computing and IoT
  ‣ augmentation of the environment
DIFFERENT FORMS OF AUGMENTATION

- Integrating further forms of augmentation besides AR/MAR
- pervasive/ubiquitous computing and IoT
  - augmentation of the environment
- wearable/mobile computing
  - human augmentation
“COMPUTATION AS AUGMENTATION” PERSPECTIVE

Back to Engelbart’s work (1962)
- framework for human intellect augmentation
MAIN IDEA & OBJECTIVE
MAIN IDEA & OBJECTIVE

• Augmented worlds as interesting systems from a computational / programming / software engineering perspective
  - novel and interesting issues
  - blueprint for developing new kinds of software systems & applications
    • e.g. hands-free systems, collaborative environments
MAIN IDEA & OBJECTIVE

• Augmented worlds as interesting systems from a computational / programming / software engineering perspective
  - novel and interesting issues
  - blueprint for developing new kinds of software systems & applications
    • e.g. hands-free systems, collaborative environments
• Focus
  - looking for high-level computation and programming abstractions and frameworks for designing and programming augmented worlds
  - interesting context for applying concurrent objs, actors, agents…
RELATED WORKS

• Location-based applications and Context-Aware computing
• Online multi-user distributed collaborative environments
  - e.g. Croquet
• Spatial Computing
  - physical space as first-order concept of the computational layer
AUGMENTED ENTITY ABSTRACTION
AUGMENTED ENTITY ABSTRACTION

- Augmented worlds shaped in terms of augmented entities
  - full-fledged computational objects
    - state + behaviour
AUGMENTED ENTITY ABSTRACTION

- Augmented worlds shaped in terms of augmented entities
  - full-fledged computational objects
    - state+behaviour
- Spatial coupling
  - location & extension
    - explicit system of reference
AUGMENTED ENTITY ABSTRACTION

- Discovery and Observability
  - lookup based and event-driven observation
  - location/distance-based filters
AUGMENTED ENTITY ABSTRACTION

• **User modelling and interaction**
  - user explicitly modelled inside the AW by proper augmented entities
    • making them observable
    • allowing them to perceive the other entities
  - multi-user applications
AUGMENTED ENTITY ABSTRACTION

- Physical embedding & coupling
  - coupling augmented entities to physical objects or phenomena
  - state synchronisation
THE MIRROR WORLD MODEL

- Augmented worlds programmed as a multi-agent system
  - agents
    - autonomous citizens of the augment world, observing and manipulating the augmented entities
  - agents’ environment
    - set of ~objects (called mirror artifacts) representing the augmented entities
PHYSICAL WORLD

MIRROR WORLD

SOFTWARE AGENTS

HUMAN USERS

OBSERVE & USE

PHYSICAL LOCATION & APPEARANCE

PHYSICAL OBJECTS

MIRROR ARTIFACTS
A FIRST PLATFORM FOR MIRROR WORLDS
A FIRST PLATFORM FOR MIRROR WORLDS

- Based on JaCaMo Framework for multi-agent programming
  - Jason agent programming language + CArtAgO Java API for implementing the environment
A FIRST PLATFORM FOR MIRROR WORLDS

• Based on JaCaMo Framework for multi-agent programming
  - Jason agent programming language + CArtAgO Java API for implementing the environment
• API for developing a MW as a “normal” agent-based systems
  - API for implementing augmented entities as mirror artifacts
  - API for allowing agents to discover/manipulate augmented entities
EXAMPLE #1: “HELLO, MIRROR WORLD!”
EXAMPLE #2: GHOSTS AND TRACES
RESEARCH AGENDA
RESEARCH AGENDA

• Exploring augmented world programming and development
  - principles and techniques
    • modularity, compositionality, reusability & extensibility
  - supporting tools
    • debugging, profiling, simulating
RESEARCH AGENDA

- Exploring augmented world programming and development
  - principles and techniques
    - modularity, compositionality, reusability & extensibility
    - supporting tools
      - debugging, profiling, simulating
  - Real-world case studies
    - collaborative hands-free systems for rescue
CHALLENGES
CHALLENGES

• Synchronization between the physical layer and the mirror layer
  - real-time, distribution
CHALLENGES

• Synchronization between the physical layer and the mirror layer
  - real-time, distribution
• Low-level/enabling-layer challenges
  - AR-related - location, tracking, registration