

Software Development Challenges for Ubiquitous Augmented Reality

GI Workshop

Virtuelle und Erweiterte Realität

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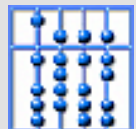
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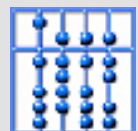
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September 28, 2004



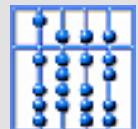
Summary

- **Ubiquitous augmented reality** is the convergence of augmented reality and ubiquitous computing.
- This convergence allows several promising **applications**.
- Building such systems presents **software engineering** challenges:
 - **Uncertainty**: users' mobility changes availability of distributed devices
 - **Ill-defined requirements**: interaction metaphors are being researched and users' preferences change
 - **Near-real-time performance**: needed to create convincing AR experience
- These challenges must be addressed by the **development process**, the **software architecture** and the **run-time infrastructure**.



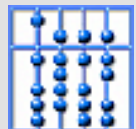
Ubiquitous Augmented Reality

- Convergence of two interaction technologies
- Augmented reality: larger range, more devices, more users
 - classical AR: track position and orientation, superimpose virtual objects into view
 - more devices for input (multi-modality) and output (multi-media)
 - greater range: mobile AR, outdoor AR
 - many users: collaborative AR
- Ubiquitous computing: richer, natural interaction techniques
 - computing technology in environment without thinking about it as such
 - applications in home, workspace; user focuses on other activities
 - other users bring new devices, providing new services
 - goal: enhance and augment the real world
- Convergence Investigated by several groups (e.g. Klinker, Schmalstieg, Butz)



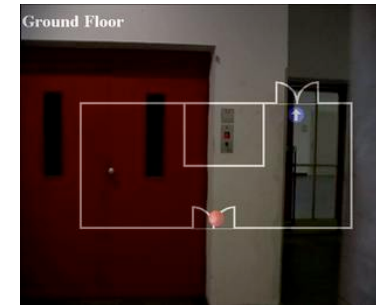
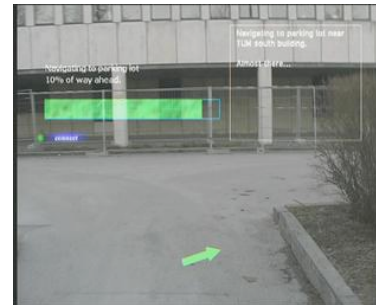
A Definition of UAR

- **Augmented Reality (Azuma)**
 - combines real and virtual
 - is interactive in real time
 - is registered in three dimensions
- **Ubiquitous Computing (Weiser)**
 - makes computers available throughout the physical environment
 - makes them effectively invisible to the user
 - augments the real world
- **Ubiquitous Augmented Reality (proposed definition)**
 - augments the real world with virtual information
 - is interactive in real time
 - is spatially registered
 - is available throughout a large physical environment
 - allows both immersive interaction and unobtrusive assistance

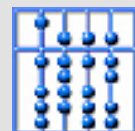


Relevance: Applications

- Navigation



- Construction and Maintenance

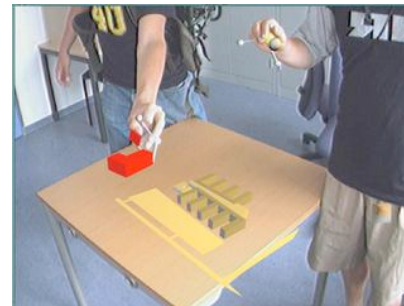


Relevance: Applications (2)

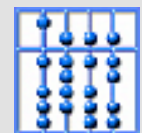
- Games



- Collaborative design

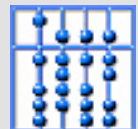


- Hospital, intelligent campus, exploration, team action...



Challenges in Software Development

- Workable solutions to some problems in AR are available
 - e.g. commercial optical tracking; scene graph rendering engines
 - Convincing static AR systems can be built (e.g. in surgery)
- Ubicomp applications are becoming more numerous
 - but low degree of immersivity and interactivity
- But: building *UAR* systems is an unsolved problem
- One reason: software engineering challenges
 - **Uncertainty**: dynamically combine distributed software components
 - **Ill-defined requirements**: young field; users' preferences change
 - **Near-real-time performance**: needed to create convincing AR experience
- Those are the challenges I am investigating in my dissertation
 - ...although, of course, there are many others.

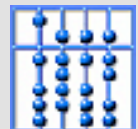


Uncertainty

Problem: At system run time, which software components should be combined, and how?

Forces:

- Distributed, interdependent hardware devices
 - Mobile and stationary (handheld, room-based tracker)
 - Computing, network, input, output
- Changing availability of devices
 - Users move about
 - Limited sensor range
- Changing context influences components and system structure
 - Use devices that are “close” to the user (in position, or in context)
- Incomplete knowledge of software components
 - stepwise deployment, different administrative domains

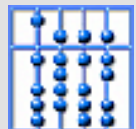


III-Definition

Problem: What should the system do, anyway?

Forces:

- New and changing technology
 - Interaction metaphors are still being researched
 - Difficult for users to imagine
- Many people and many disciplines involved
 - Different users have different preferences
 - Different disciplines have different languages
- Requirements elicitation is difficult
 - Users involved in real-world tasks; computers of secondary interest
- New applications
 - Users will want to recombine deployed components in different ways

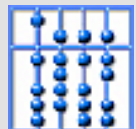


Performance

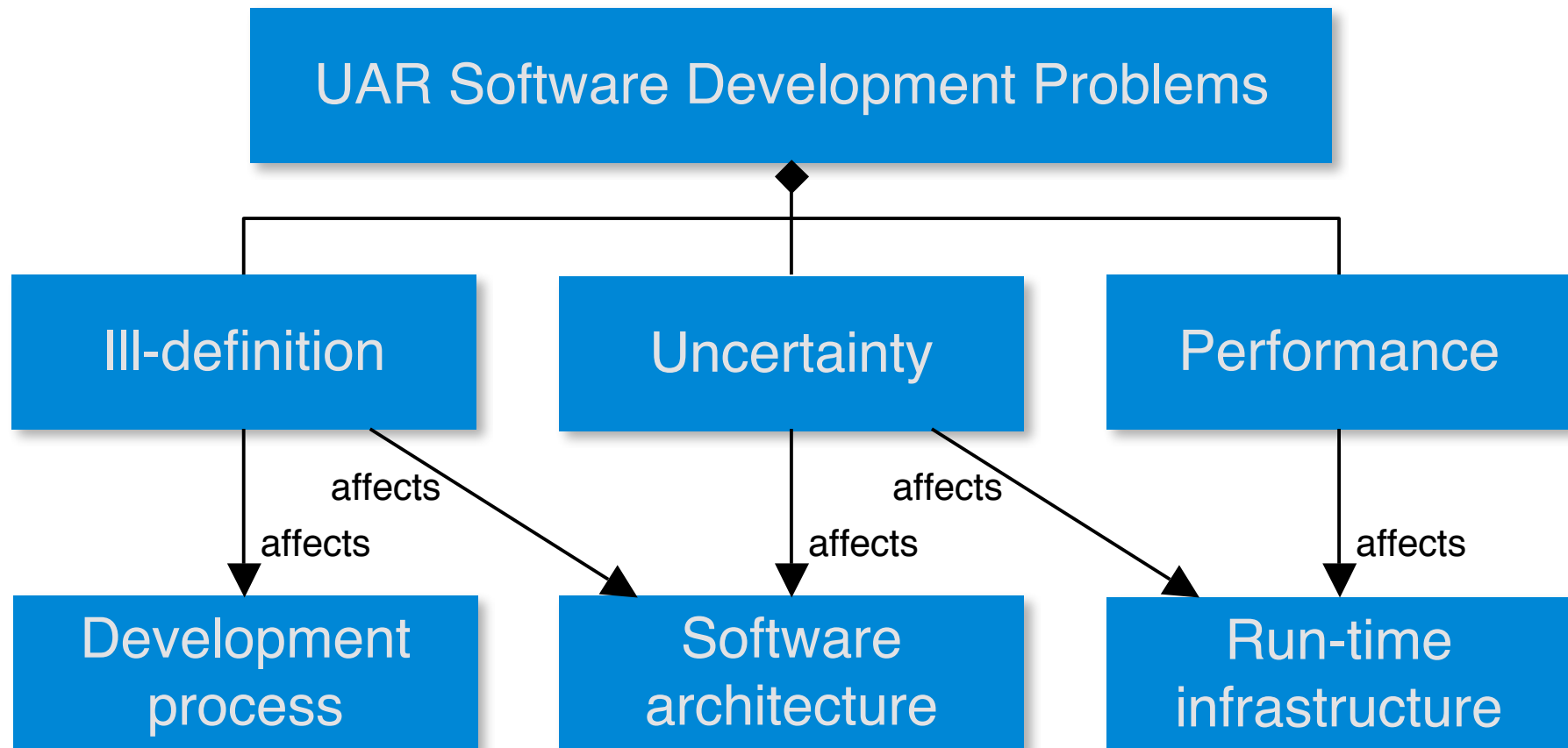
Problem: System must deliver near-real-time performance in large distributed environment

Forces:

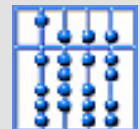
- Immersivity for convincing AR user experience
 - Low overall lag between head tracking and 3D rendering; 20ms
 - High update rate, 30 fps
- Scalability in ubiquitous computing environment
 - Many users must have access to same sensor data
 - Users' mobile devices should collaborate
- Many data and communication types
 - Video streams, sensor data streams, semantic events, transactions...



Towards a Solution

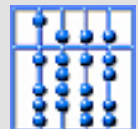


- Must balance forces in different aspects of software development
- Tradeoffs— e.g. dynamic adaption can degrade real-time performance



Conclusion

- Ubiquitous augmented reality is a promising field
- There are fundamental problems to be solved in how to develop software for it
- The three problems of...
 - uncertainty
 - ill-definition
 - performance...affect the choice of...
 - software architecture
 - middleware, run-time infrastructure
 - development process...and should be considered carefully in planning them.



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Thank You for Your Attention!
Any Questions?

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