

# Software Development Challenges for Ubiquitous Augmented Reality

GI Workshop

*Virtuelle und Erweiterte Realität*

Asa MacWilliams

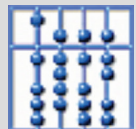
Lehrstuhl für Angewandte Softwaretechnik

Institut für Informatik

Technische Universität München

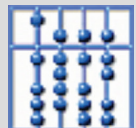
macwilli@in.tum.de

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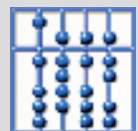
# Summary

- **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**.



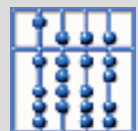
# Ubiquitous Augmented Reality

- 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)



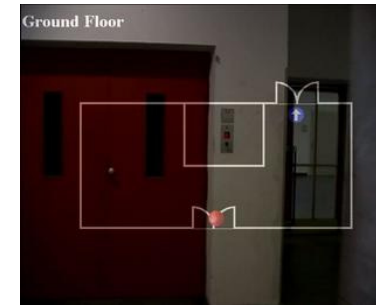
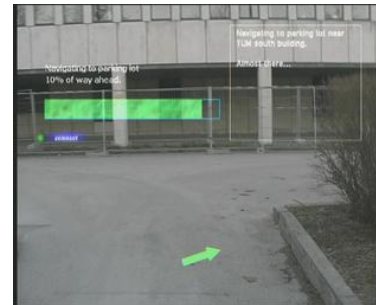
# A Definition of UAR

- **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

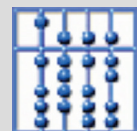


# Relevance: Applications

- Navigation



- Construction and Maintenance

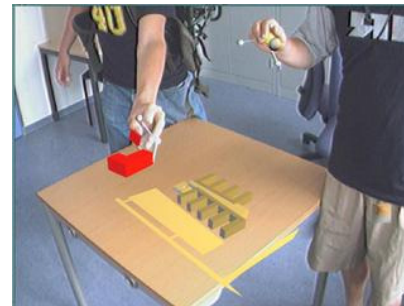


# Relevance: Applications (2)

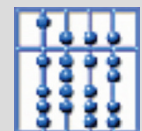
- Games



- Collaborative design

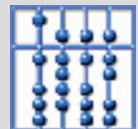


- Hospital, intelligent campus, exploration, team action...



# 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.

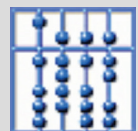


# Uncertainty

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



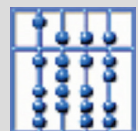


# III-Definition

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

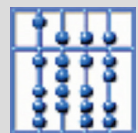


# Performance

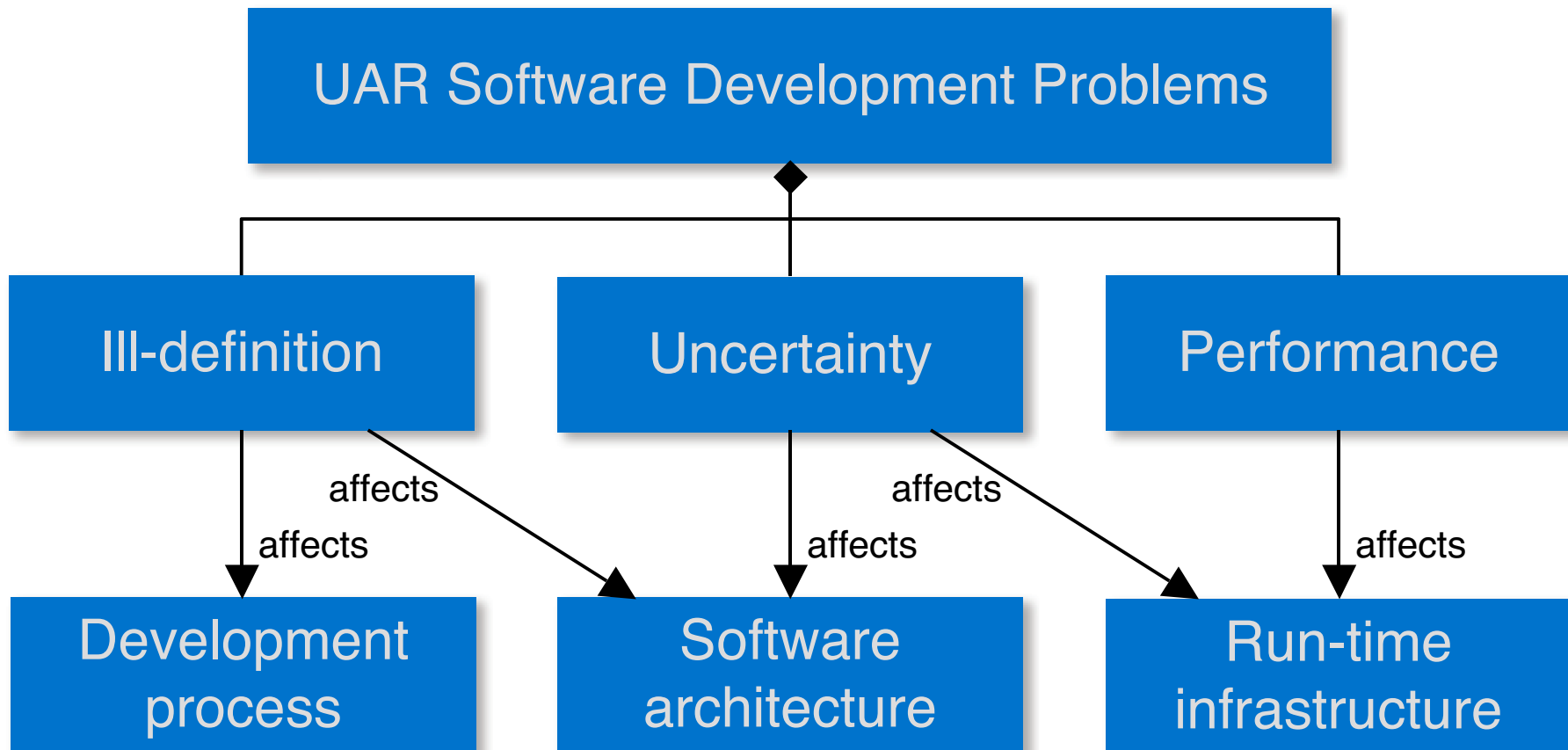
Problem: System must deliver near-real-time performance in large distributed environment

Forces:

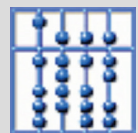
- Immersivity for convincing AR user experience
  - Low overall lag between head tracking and 3D rendering; 20ms
  - High update rate, 30 fps
- Scalability in ubiquitous computing environment
  - Many users must have access to same sensor data
  - Users' mobile devices should collaborate
- Many data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



# Towards a Solution

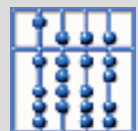


- Must balance forces in different aspects of software development
- Tradeoffs— e.g. dynamic adaption can degrade real-time performance



# 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?

[macwilli@in.tum.de](mailto:macwilli@in.tum.de)

