Attention and Interruption in Massive Multimodal Ubiquitous Computing Environments

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In instrumented environments all modalities matter on a large scale

Speech

Graphics

Gestures

Multimodal Interaction

Biometric

implicit and explicit physical actions

Mimics

Massive Multimodal Computing

- Many users, large interaction spaces
- Large amount of modality sensors
- Many degrees of freedom for users

Challenges

- Attention and interruption handling
- Calibration
- Software-Architectures and toolkits

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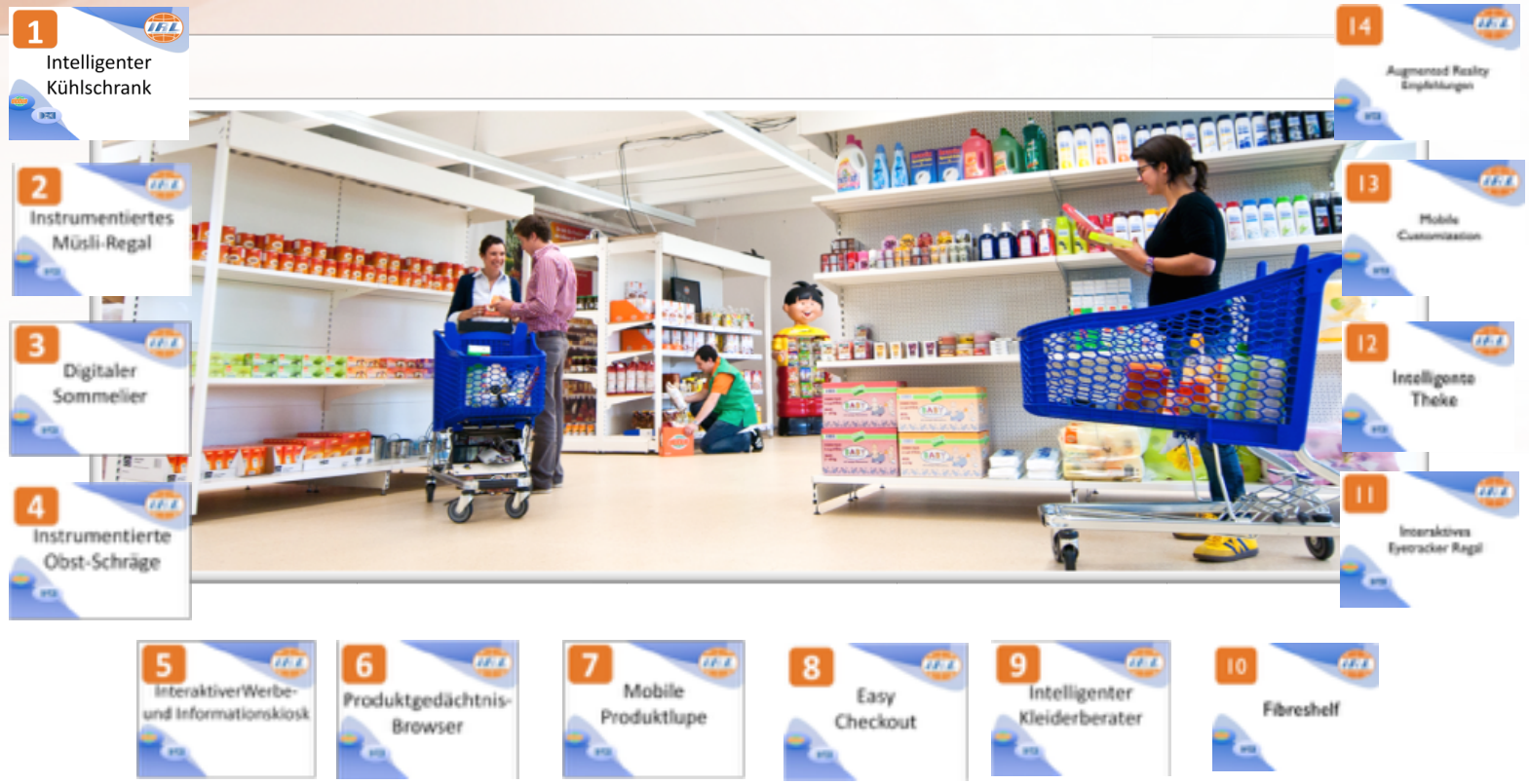
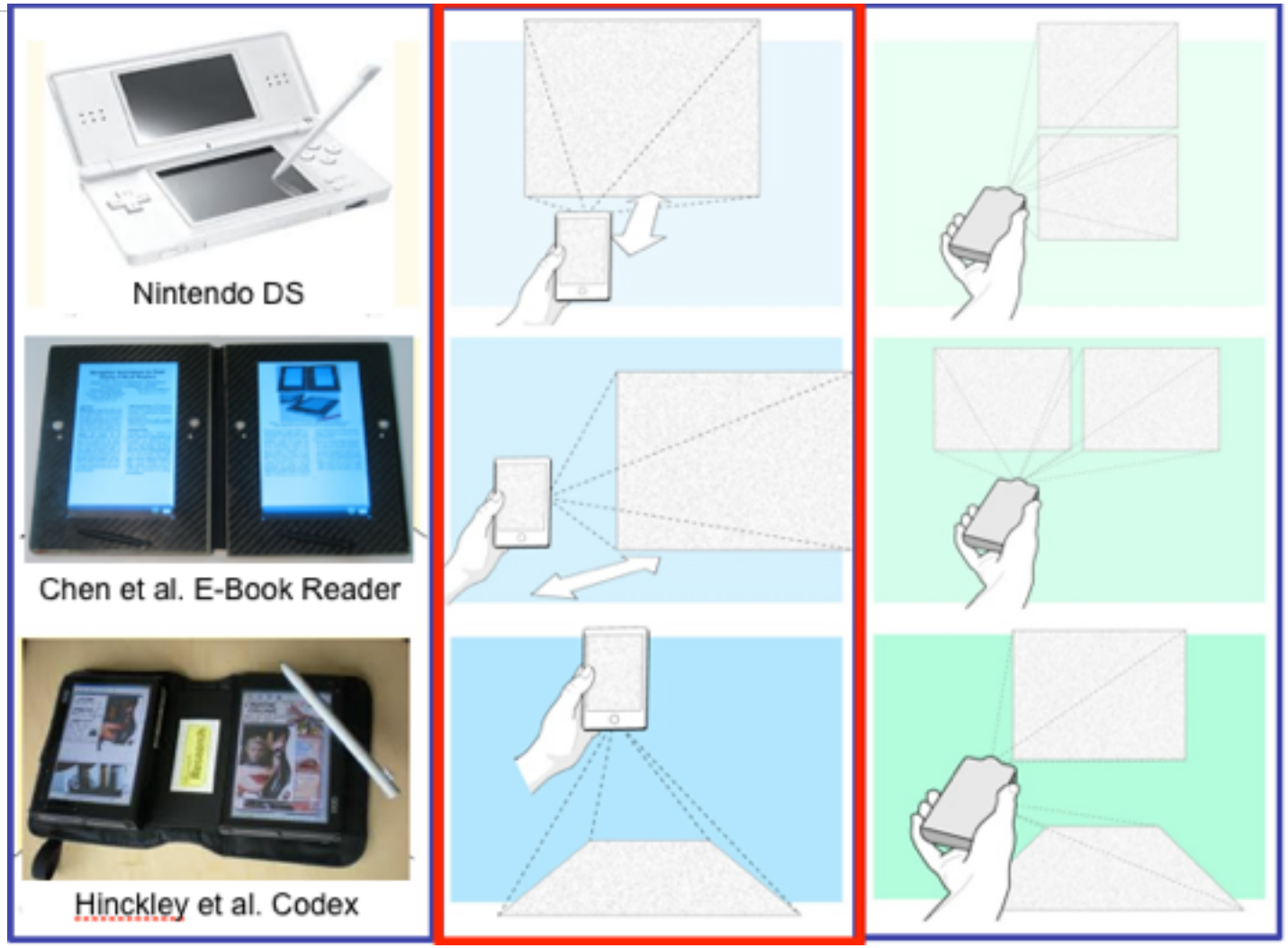


Instrumented Space with several evolving demonstrators (currently more than 14)

Research Topics: digital product memory, RFID, event-based architectures, intelligent user interfaces for instrumented spaces

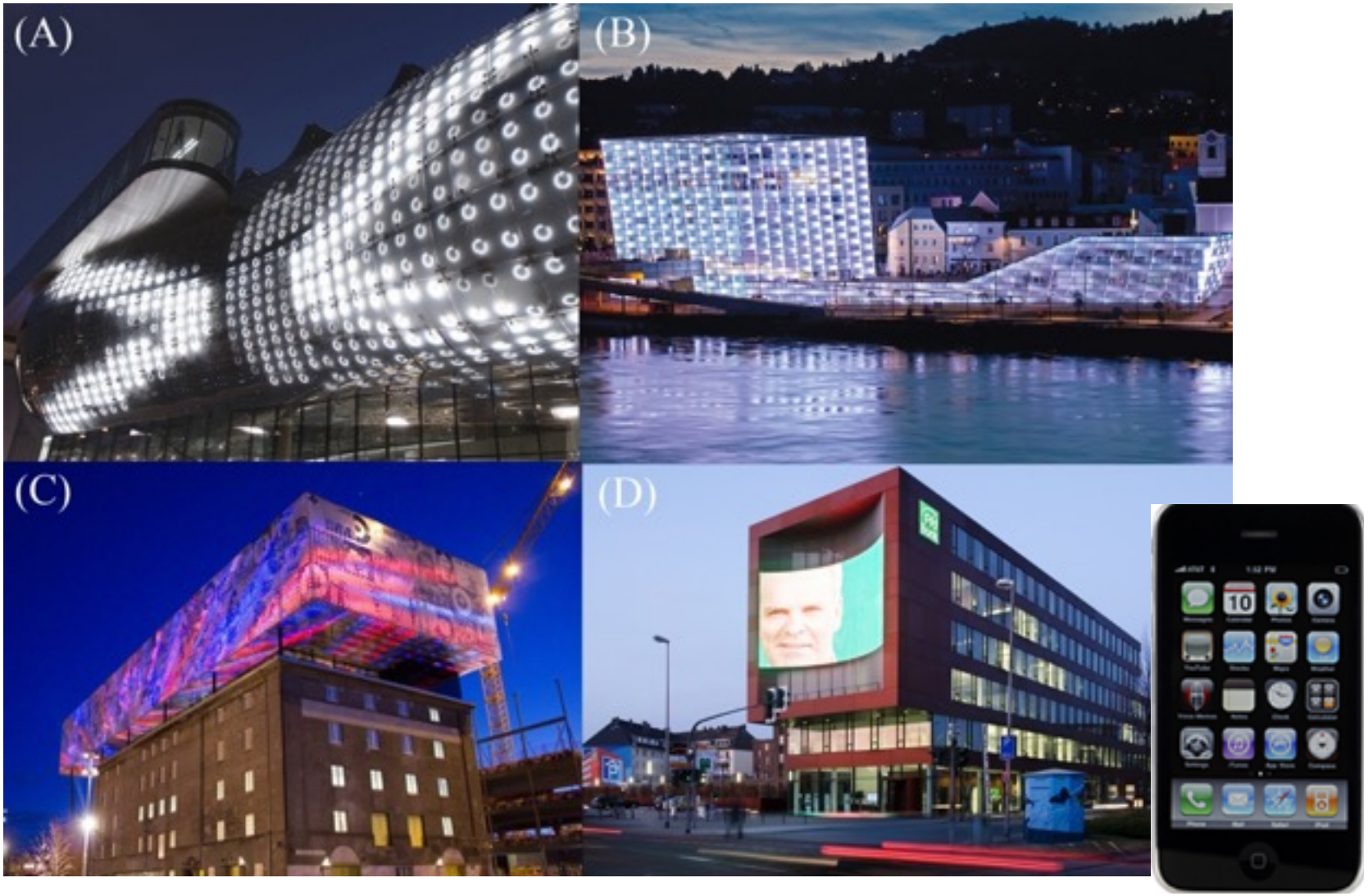
Scientific Methods of Artificial Intelligence, Human-Computer-Interaction, User-Centered Design, and Datamining

Investigating mobile multi-display projection environments



Cauchard, Löchtefeld, Irani, Schöning, Krüger, Fraser, Subramanian: Visual Separation in Mobile Multi-Display Environments, UIST 2011.

Interaction with Media Facades using Handheld Displays



Gehring, Krüger: The Media Facade Toolkit: Prototyping and Simulating Interaction with Media Facades, Ubicomp, 2013.

Why bother about attention?

- huge amount of visual information

http://www.travelhouseuk.co.uk/news/wp-content/uploads/New-York-Time-Square.jpg (03.12.2013)

Why bother about attention?

- huge amount of visual information

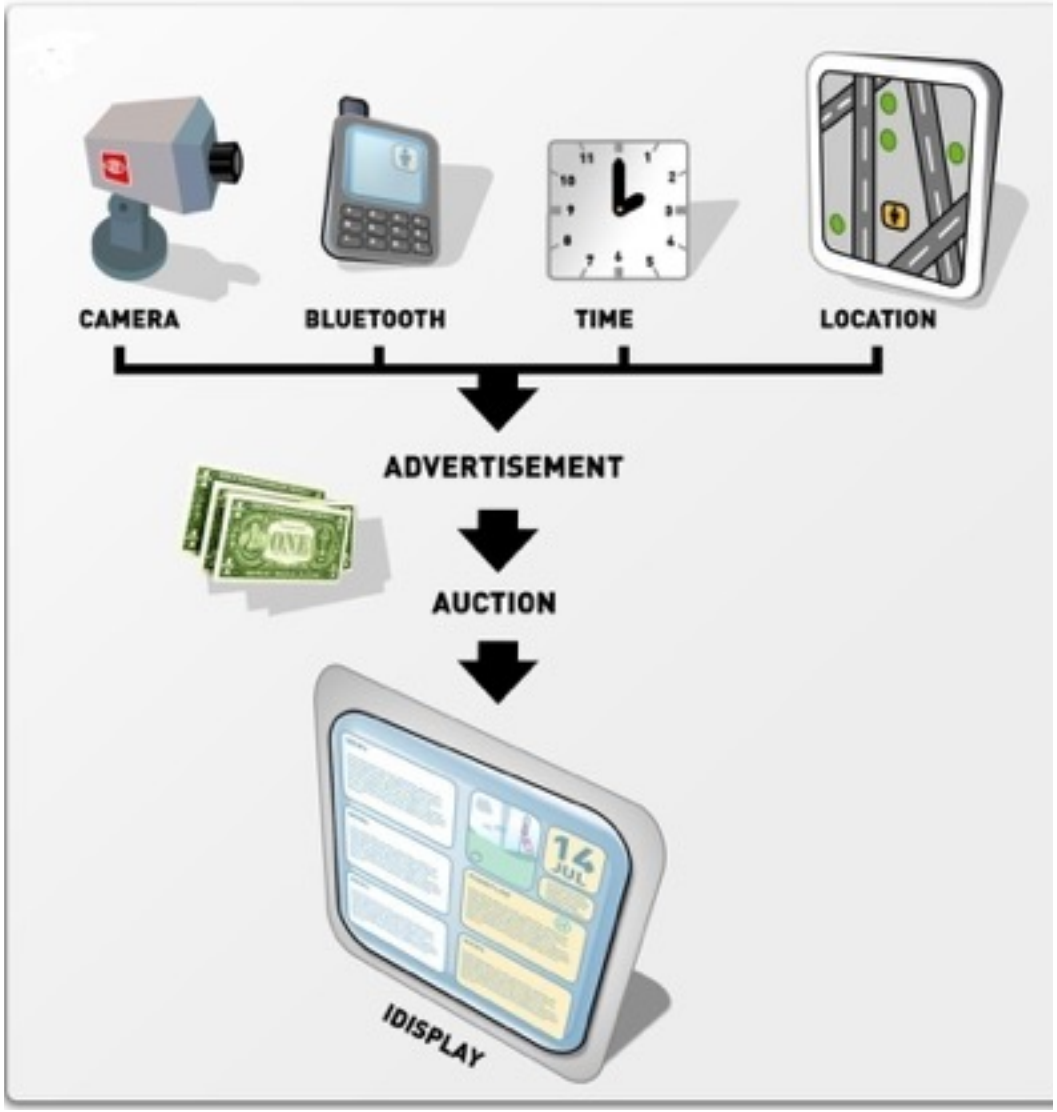
http://www.zdf.de/ZDF/zdfportal/blob/4969968/1/data.jpg (03.12.2013)

Environmental pollution of attention grabbers

Trading of attention certificates

Müller, Krüger: Competing for your Attention: Negative Externalities in Digital Signage Advertising, DaEAIS, Workshop at Pervasive 2007, 2007

Bidding on user's attention



Jörg Müller, Antonio Krüger, Tsvi Kuflik: *Maximizing the Utility of Situated Public Displays.* Proceedings of User Modeling 2007, Springer, 2007.

Types of Attention

Visual Attention

- not possible to perceive all visual information at once
- "[...] spotlight that enhances the efficiency of detection of events within its beam."[3]

http://www.uxmatters.com/mt/archives/2013/03/images/Hoober-TaughtAboutTouch-Fig3.png (04.12.2013)

http://www.sciencecodex.com/aggregated-images/brain/zdzjmGkLSR6qi158.jpg (04.12.2013)

Auditory Attention

- "Cocktail-Party-Effect"[4]*:* ability to focus on one speaker by filtering out other conversations/ noise in the room

Haptic attention

- Usually restricted to contact, but remote haptic feedback is coming

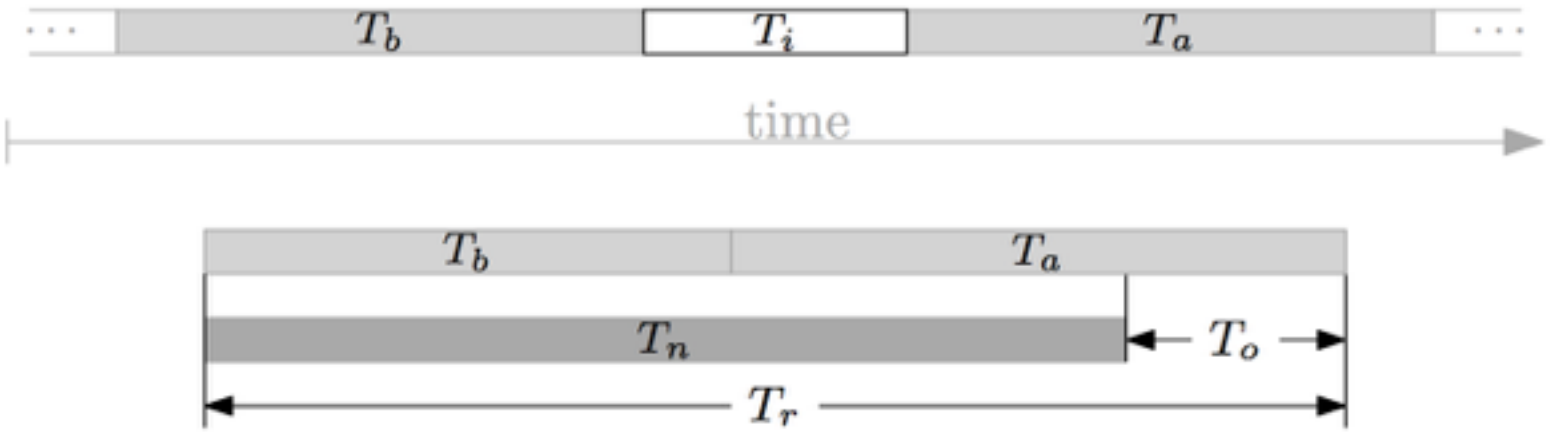
[3] Posner, M. I., Snyder, C. R. R. and Davidson, B. J. (1980): Attention an the detection of signals. Journal of Experimental Psychology: General.

[4] Cherry, E. Colin (1953): Some experiments on the recognition of speech, with one and with two ears. Journal of the Acoustical Society of America 25, 975–979

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm	% of Total Launches	Users	Apps
Browser	7.9%	7.7%	7.8%	7.6%	7.3%	7.4%	7.0%	7.9%	8.1%	8.0%	7.7%	7.3%	7.0%	6.9%	6.8%	6.4%	6.6%	6.6%	6.4%	6.6%	7.0%	7.4%	7.5%	7.4%	6.83%	2,398	9
Comics	4.5%	5.2%	5.4%	5.8%	5.8%	5.6%	5.5%	5.2%	5.4%	5.1%	4.7%	4.3%	4.3%	4.2%	4.2%	4.3%	4.4%	4.0%	4.4%	4.2%	4.1%	4.1%	4.1%	4.4%	4.31%	2,151	1,810
Communication	44.9%	41.1%	38.3%	35.4%	31.6%	31.8%	32.7%	34.7%	39.4%	44.8%	49.0%	52.6%	54.8%	55.2%	55.2%	56.1%	55.7%	56.8%	57.1%	56.1%	54.8%	53.3%	52.0%	49.0%	49.50%	2,769	550
Entertainment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.02%	126	43
Finance	0.2%	0.3%	0.3%	0.2%	0.1%	0.1%	0.1%	0.2%	0.3%	0.3%	0.4%	0.5%	0.3%	0.3%	0.4%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.25%	604	164
Games	3.2%	3.0%	3.0%	2.7%	2.5%	2.3%	2.2%	1.7%	1.9%	1.9%	2.0%	2.1%	2.2%	2.2%	2.2%	2.3%	2.3%	2.2%	2.2%	2.4%	2.7%	3.0%	3.0%	3.2%	2.30%	1,716	1,702
Health	0.3%	0.4%	0.4%	0.4%	0.6%	0.6%	0.7%	0.6%	0.4%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.2%	0.3%	0.2%	0.3%	0.26%	540	227
Libraries & Demo	0.4%	0.5%	0.6%	0.7%	0.9%	0.8%	0.7%	0.6%	0.5%	0.4%	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.30%	1,267	117
Lifestyle	0.8%	0.9%	1.0%	1.4%	1.3%	1.5%	1.4%	1.4%	1.1%	0.9%	0.6%	0.6%	0.5%	0.5%	0.5%	0.5%	0.6%	0.5%	0.3%	0.4%	0.4%	0.5%	0.5%	0.5%	0.60%	2,132	451
Multimedia	2.1%	2.1%	2.4%	2.4%	2.7%	2.4%	1.8%	1.8%	1.9%	1.7%	1.8%	2.0%	2.0%	2.0%	2.2%	2.1%	2.2%	2.4%	2.3%	2.3%	2.2%	2.1%	1.9%	2.0%	2.03%	1,713	76
News	2.6%	2.5%	2.6%	2.5%	2.5%	2.7%	3.3%	3.7%	4.1%	3.6%	3.0%	2.6%	2.5%	2.7%	2.5%	2.4%	2.2%	2.1%	2.3%	2.2%	2.3%	2.2%	2.3%	2.3%	2.46%	1,777	440
Productivity	3.6%	5.0%	5.0%	5.8%	6.3%	6.5%	6.0%	5.4%	4.8%	5.1%	4.9%	4.3%	4.2%	4.0%	4.0%	3.7%	3.4%	3.4%	3.0%	3.1%	3.1%	3.0%	2.9%	3.2%	3.76%	2,190	648
Reference	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.7%	0.5%	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.3%	0.4%	0.4%	0.4%	0.5%	0.5%	0.5%	0.6%	0.47%	903	346
Settings	1.3%	1.6%	1.5%	1.3%	1.6%	1.2%	1.2%	1.1%	1.3%	1.4%	1.4%	1.4%	1.2%	1.3%	1.2%	1.2%	1.3%	1.1%	1.1%	1.2%	1.2%	1.3%	1.3%	1.4%	1.23%	2,178	1
Shopping	3.9%	4.5%	3.7%	3.4%	3.2%	3.2%	3.1%	3.0%	3.1%	3.3%	3.2%	3.2%	3.2%	2.8%	2.9%	2.9%	2.7%	2.7%	2.7%	2.7%	2.8%	3.1%	3.6%	3.5%	2.96%	2,556	198
Social	5.7%	5.0%	4.9%	4.3%	4.2%	4.0%	4.4%	5.1%	5.3%	5.4%	5.2%	5.0%	4.7%	4.8%	4.9%	4.5%	4.5%	4.6%	4.6%	4.9%	5.2%	5.4%	5.8%	5.7%	4.77%	1,902	342
Sports	0.5%	0.3%	0.3%	0.2%	0.3%	0.3%	0.2%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.6%	0.7%	0.8%	0.9%	0.8%	0.6%	0.6%	0.7%	0.8%	0.7%	0.7%	0.56%	571	215
Themes	0.2%	0.1%	0.2%	0.3%	0.4%	0.4%	0.4%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.14%	249	231
Tools	10.9%	12.2%	14.6%	17.6%	20.3%	21.5%	21.4%	18.6%	14.7%	10.4%	8.4%	6.8%	6.1%	5.9%	5.9%	5.9%	6.0%	6.1%	5.8%	6.0%	6.3%	6.8%	7.4%	9.1%	7.89%	2,512	1,688
Travel	1.4%	1.6%	2.1%	2.2%	2.4%	2.6%	2.2%	1.9%	2.0%	2.1%	2.0%	1.8%	1.9%	1.9%	1.9%	1.8%	2.0%	1.9%	2.2%	2.2%	1.9%	1.7%	1.6%	1.4%	1.86%	1,752	407
Unknown	4.7%	5.3%	5.1%	5.0%	5.3%	4.4%	5.0%	5.9%	4.6%	4.4%	4.1%	3.8%	3.5%	3.8%	3.7%	3.7%	4.0%	3.6%	3.7%	3.7%	3.7%	3.9%	4.1%	4.5%	3.88%	2,284	1,796
Total Launches per Hour	103,604	77,053	53,633	40,332	33,438	30,949	38,161	56,895	83,488	109,550	127,069	142,642	158,876	168,062	169,018	172,935	173,963	179,801	184,012	176,050	163,080	153,835	141,303	123,639			

Investigating Mobile Interruptions with Appazaar Data

Data samples	Days of study	Applications	Users
5,495,815	532	15,756	3,611



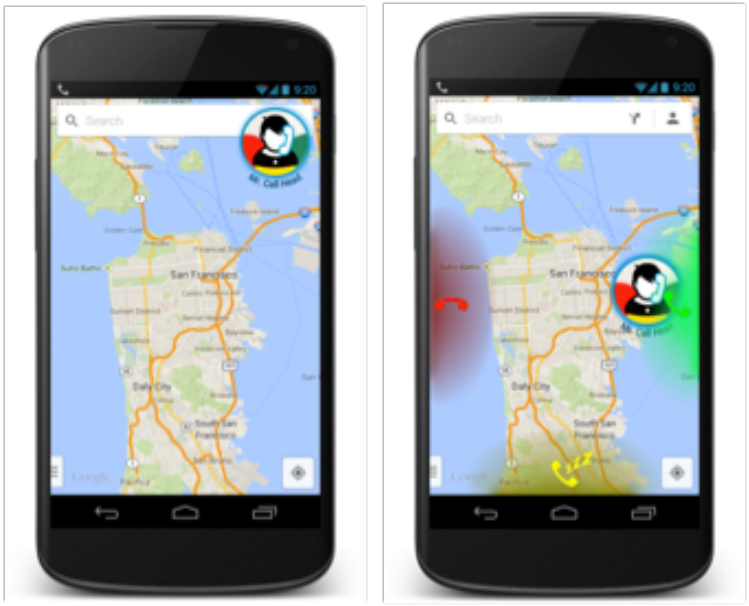
Results: Interruptions are not very frequent (10%),
but costly (up to 4x original task duration)

Preventive vs Curative Strategies

Leiva, Böhmer, Gehring, Krüger:Back to the App: The Costs of Mobile Application Interruptions, MobileHCI 2012

Strategies to mitigate interruptions in mobile computing

Not much has happened in the past to handle interruptions by incoming phone calls



Callheads allows to handle incoming calls by postponing

Böhmer, Lander, Gehring, Brumby, Krüger: Interrupted by a Phone Call: Exploring Designs for Lowering the Impact of Call Notifications for Smartphone Users, CHI 2014

Evaluation: lab and **app-store** study

	#cases	*#users*	*per user*
Incoming calls total	**88,516**	**525**	**168**
... non-interruptive	**59,608**	**519**	**114**
... interruptive	**28,908**	**525**	**54**
Interruptive calls accepted	**16,119**	**509**	**31**
...after being postponed	**106**	**79**	**1**
Interruptive calls declined	**2,311**	**317**	**7**
...after being postponed	**114**	**78**	**1**
Interr. calls unanswered	**10,476**	**468**	**149**
...after being postponed	**539**	**206**	**2**
Postpone events	**770**	**247**	**3**
Widget move events	**3,048**	**403**	**7**

Table 1. Descriptive stats on number of calls and events.

Managing Attention for secondary tasks

Gazemarks: Interacting with maps while driving

Kern et al: Gazemarks: gaze-based visual placeholders to ease attention switching." CHI 2010.

Managing and Guiding Attention

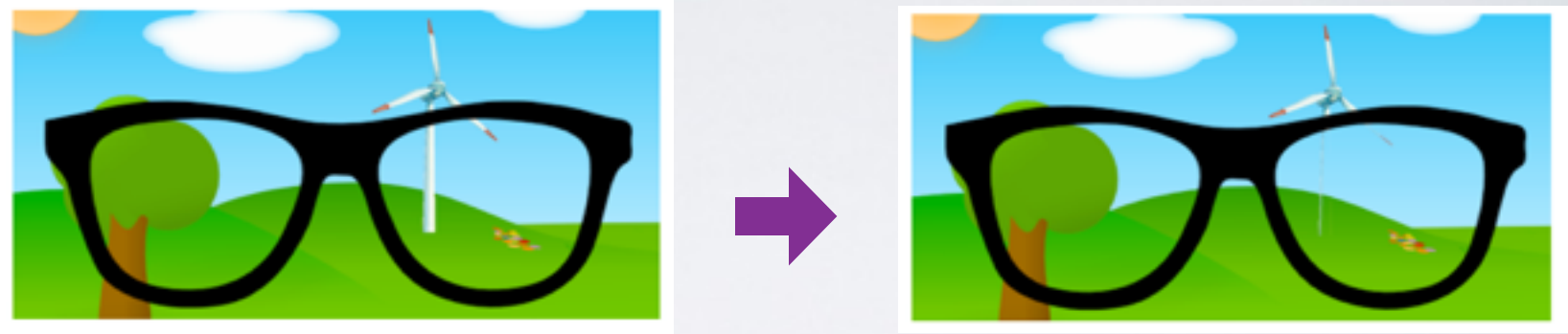
Project „SADiS - Smart Attention-Directing Shelf“

funded by the Federal Ministry of Education and Research within the initiative „Software Campus“

Direct visual attention of customers in smart retail environments to predefined products in a shelf

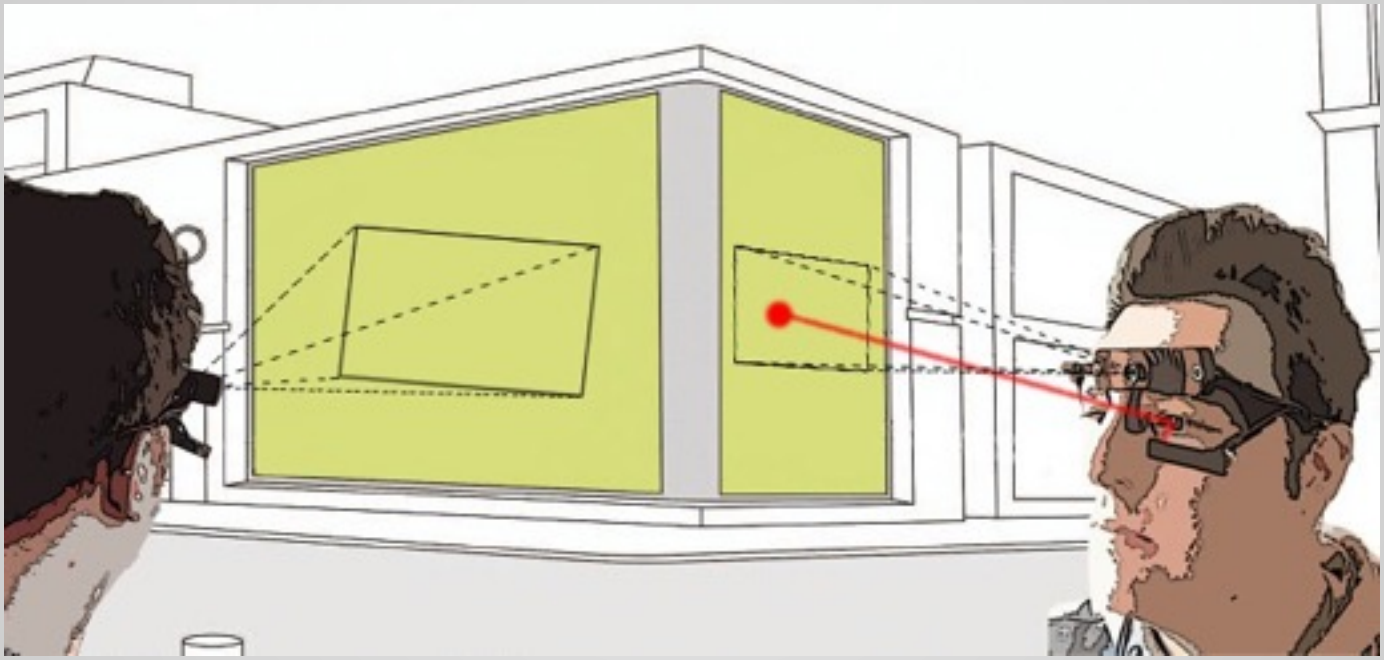
Diminished and filtered Reality

Goal: Attention-driven persuasive systems



http://centrefold.deborre.net/wp-content/uploads/2012/08/Inclusive-Airport-Navigation_Chapter-3_fra_2.jpg (03.12.2013)

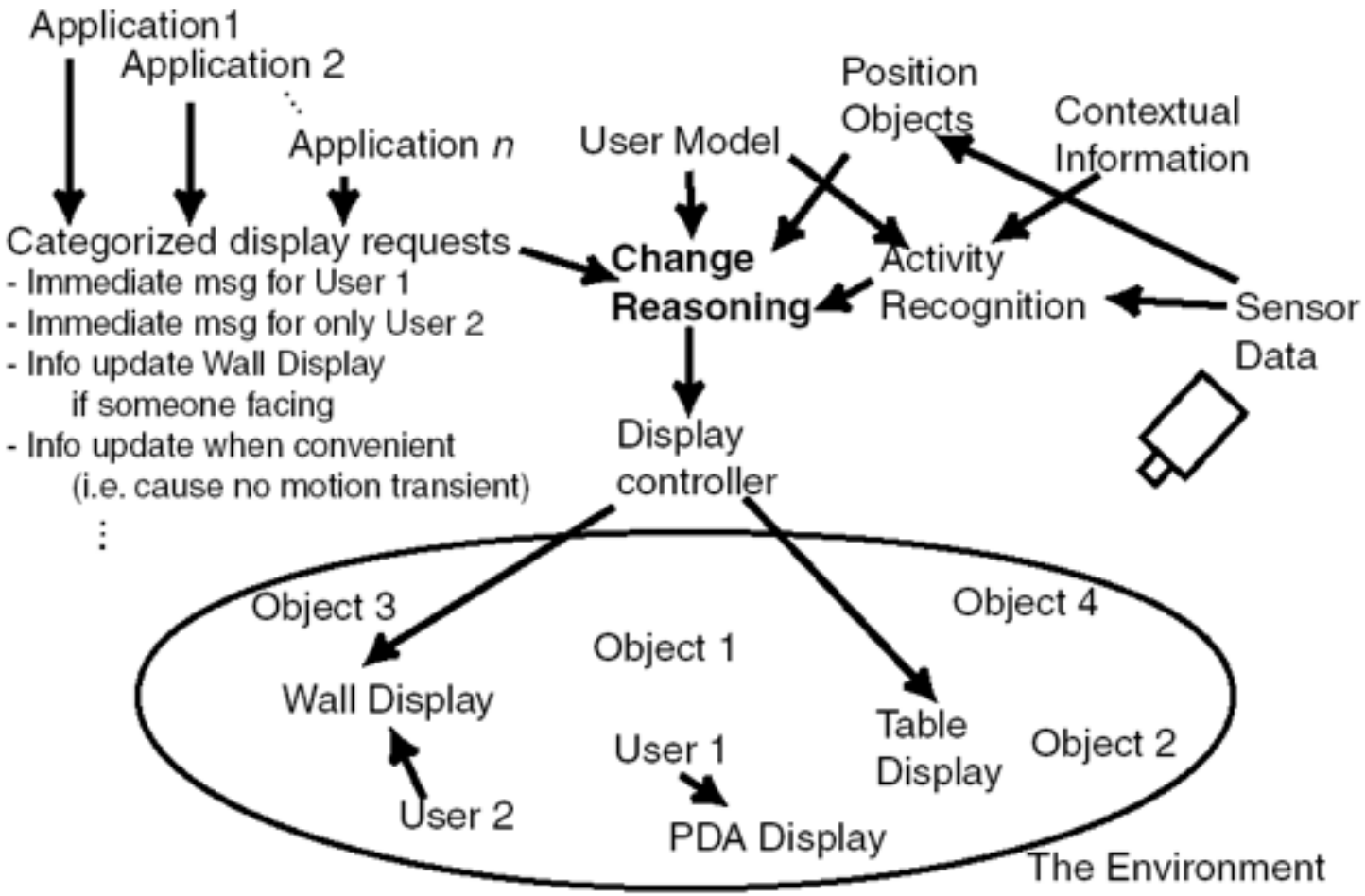
IN-THE-WILD CALIBRATION



Use screen content to provide calibration

ONE CALIBRATION PER ENVIRONMENT

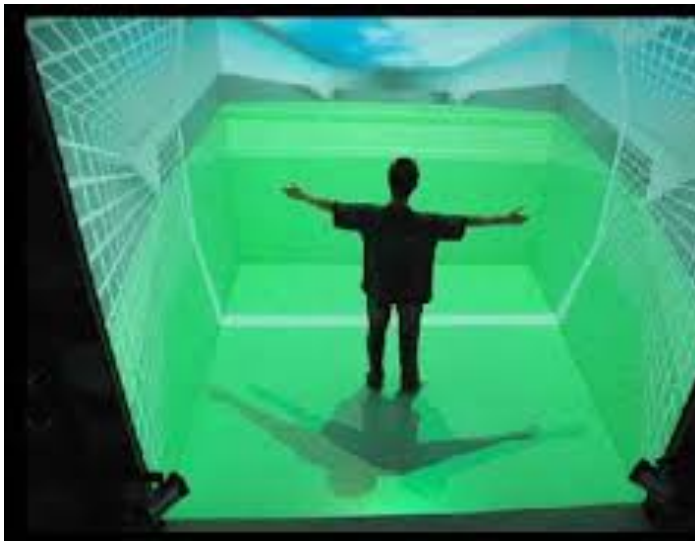
Managing Change Blindness



Intille: Change Blind Information Display for Ubiquitous Computing Environments, UbiComp 2002

Dual Reality, Solving Tasks and Attention Guidance

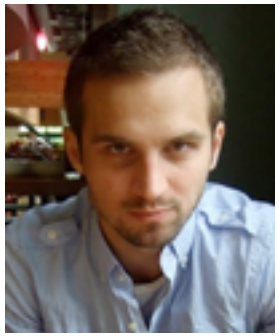
Attention with new embodied senses?



Team members and topics

Christian Lander
Mobile Computing, Gaze-Interaction

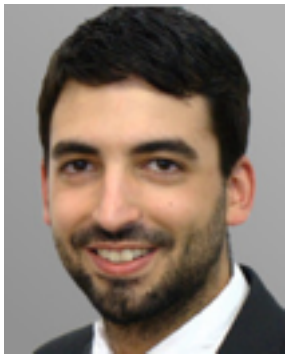
Florian Daiber
Stereoscopic UIs, Touch UIs



Alex de Luca
Usable Privacy & Security

Frederic Kerber
Ergonomics and Embodied HCI

Denise Paradowski
Mobile Computing
Attentive UIs



Tobias Leidinger
Ergonomics and Embodied HCI

Pascal Lessel
Touch and UI,
Persuasive and social Computing

Gerrit Kahl
Instrumented Spaces, **Event-Architectures, 3D-Interaction**

Markus Löchtefeld
Mobile Projection AR-Interaction
Mobile Interaction

Frederic Raber
SW- Architectures for Instrumented Spaces
Usable Privacy

Sven Gehring
Mobile Computing,
Media Facades

Marco Speicher
Morphable and Touch UIs