Smartphone Augmented Reality
Context is King

Clark Dodsworth
Product Strategy, Innovation & Development
Process of tool design

Empathic pragmatism
Broad-based tool knowledge / pattern recognition / intuitive

Perspective
“Product as tool as interface”
Tool should adapt to you.

Work
User-centered product strategy, dev, design.
Projects

AR

VideoCart, ‘92: Location-aware mobile retail touch-screen kiosk network with data-driven path mapping.

“Ambient Intelligence” strategy,’98: Philips Consumer Electronics.

Royal Tyrell Museum, Alberta, ‘06: Smartphone AR paleontology exhibit complex across 11 remote archaeological sites.

Dubailand theme park, ‘08: hyperpersonalized smartphone AR experience.

Other Tech

SimEx-Iwerks ’93–’07: Product strategy in high-tech entertainment.

The Leonardo museum, ’07: Design: pervasive 24/7 social relationships with their public.
VideoCart: mobile *location-aware* touchscreen retail, ’92
Live Wall: videophone design

Philips, ‘98
“Ambient Intelligence” strategy

Philips, ‘98
The Leonardo, Salt Lake City ‘07

The Leonardo Digital User Experience

The Leonardo Staff User Experience

The Leonardo Digital Program Operations

The User Community

Off-Site Hosting

Some department-specific applications; unsubscribe list, regularly posted data sets or newer data from online databases.
Alfred North Whitehead (1861-1947)
Mathematician, philosopher & first augmented reality theorist

#1: “Civilization advances by extending the number of important operations which we can perform without thinking of them.”
   ...AR shouldn’t increase cognitive load

#2: “The art of progress is to preserve order amid change and to preserve change amid order.”   ...AR: contextually dynamic data management & display

#3: We think in generalities, but we live in detail.”
   ...AR tasks: managing detail
Prehistory, soon after invention of the sail.

~1900
Horse carriages

1958
1st jet fighter heads-up display

1970s
US DoD air-combat testing

1974-8
1st car HUD: Cutlass Supreme

1988
“Augmented environments,” sensor nets

1992+
Dedicated tools begin: ARToolkit UW HITLab

1999
1999
1st car HUD: Cutlass Supreme

2006
Nokia’s MARA

20??
Efficient power usage

The goal

Hands-up displays

“UbiComp”: Mark Weiser & David Mizell

“UbiComp”: Mark Weiser & David Mizell

Commercial helmet-mounted displays

Sutherland/Sproull, ’68: 1st HMDs

Commercial aviation
Reed sails on boats in the prehistoric Middle East had inherent sail-edge tell-tales.

Sensor/display fusion
Marmon Wasp racecar, 1911

Heads-Up Display:
Rear view mirror just above sight line.
History: AR Timeline

- Sailboat tell-tales
- Rear-view mirrors

1. Prehistory, soon after invention of the sail.
   - ~1900 Horse carriages

2. 1958: 1st jet fighter heads-up display
3. 1970s: Commercial aviation
4. 1974-8: US DoD air-combat testing
5. 1988: 1st car HUD: Cutlass Supreme
7. 1999: Dedicated tools begin: ARToolkit UW HITLab
8. 2006: Nokia’s MARA
9. 20??: Efficient power usage
10. The goal: Useful smartphone AR
11. Hands-up displays
12. Commercial helmet-mounted displays

- “UbiComp”: Mark Weiser, parc
- Tom Caudell & David Mizell

- Onage Associates
Heads-Up Displays (early)

Cintel “Buccaneer” cockpit heads-up display device, UK 1958

MIG21 heads-up display (installed): circa 1960s

photo: Rochester Avionics Archives, UK

photo: Will Hise cc
Heads-Up Display: modern commercial aviation AR
HMDs
Helmet-mounted displays

- High-priority military R&D $
- Single-function, effective for task
- Tethered to power & CPU
- Partially obstructs field of view
- Delicate to maintain
- Size/weight unacceptable to civilians
- Adds situational complexity
- State of the art = net loss of context awareness

Not general AR
HUDs
Heads-up displays

First car: Oldsmobile 1988 Cutlass Supreme International Speedometer projected on windshield.

Modern BMW E60 HUD display (orange), 2008
History: AR Timeline

- **Prehistory, soon after invention of the sail.**
- ~1900 Horse carriages
- 1958 Rear-view mirrors
- ~1900 Sailboat tell-tales
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- 1970s Commercial aviation
- 1974-8 US DoD air-combat testing
- 1988 1st car HUD: Cutlass Supreme
- “Augmented environments,” sensor nets
- Dedicated tools begin: ARToolkit UW HITLab
- 1992+ “UbiComp”: Mark Weiser
- 1999 Tom Caudell & David Mizell
- 2006 Nokia’s MARA
- **Now** Hands-up displays
- 20?? Useful smartphone AR
- The goal
- Efficient power usage
- Commercial helmet-mounted displays
- The goal
- Hands-up displays
- Sutherland/Sproull, ‘68: 1st HMDs
Current AR Scope

**AR** = Well understood in defense industries, vehicle design, games.

**AR** = Subset of Ubiquitous Computing:
Same infrastructure issues, even more privacy issues.

**AR** = *When queried* delivery of information.

WHERE WE ARE NOW

Not enough utility, personalization, interoperability.
“Hands-Up Displays”

Mobilizy's original product, “Wikitude AR (Travel) Guide,” for Android
Ubiquitous mobile broadband transition:

Texas Instruments (Feb. ‘10) introduced a 4-radio chip that delivers wireless LAN 802.11n, GPS, Bluetooth and FM transmit & receive.
Smartphone AR/Phase One activity indicators

*Ubiquitous mobile broadband transition:*

- Cisco (Feb. ‘10): “Wireless-data traffic expected to double every year through 2014. 400 million consumers will access the Internet through a mobile connection only.”

- Cisco (Oct. ‘09) bought Starent Networks ($2.9B), for wireless carriers to deliver multimedia features. Smartphones generate more than 30 x the traffic of basic cell phones.

...Wait till they see the numbers for iPad.
Smartphone AR/Phase One, recent projections

• Juniper Research (UK)
  Nov. ‘09: “By 2014, revenue from Augmented reality downloads, advertising, subscriptions, events, and content increments will reach $732M.”

• Gartner
  Dec. ‘09: “By 2013, mobile phones will replace PCs as the most common device for Web access.”

• Gartner
  Dec. ‘09: “By 2015, context will be as influential to mobile consumer services and relationships as search engines are to the Web. Context will center on observing patterns, particularly location, presence and social interactions.”

• ABI Research
  Oct. ‘09: “[Smartphone AR] revenue is poised to grow to $350M in 2014.”
Smartphone AR/Phase One: General

AR + LBS* = features, not an industry.
Will be incorporated into OS.
Requires sophisticated web services & major database backends.
Vertical markets appropriate now.
Lack of standards (OS, platforms, & apps) limits horizontal markets.

*Location-Based Services

Impending acronym fusion:
AR + LBS* + GIS + RFID + IR + etc. = the new POTS** = “my computer”

** Plain Old Telephone Service
Smartphone AR/Phase One

Hardware and Software

- GPS (slow, low-resolution)
- Layering of graphics
- Geotagging photos, > spatial DB search
- Accelerometers for gesture recognition
- Light sensors
- Proximity sensors, usually infrared
- Compass, low res.
- Touch (2D)
- Bluetooth
- 2D target icons, 2D pattern-matching
- Machine vision: object identification
Players

Mobilizy
- Wikitude World Browser & Drive

Nokia
markerless 2D, 3D: Point & Find,
Image Space, MARA

Layar
layered content svcs.: Reality Browser

Studierstube ES
rich dev. framework, 3D object tracking

Siri.com
personalization, voice rec.

Google: “Goggles”

Autodesk

NAVTEQ

The games companies

Sense Networks

Total Immersion (tools): D’Fusion Studio

Metaio (tools): Unifeye Design

Mobile Acuity, Ltd.
visual search: marketing

Torchidot

Ogmento
markerless feature tracking

Pongr.com
image recognition: mobile retail

Aloqua.com
personalized locational info

Mobile Sorcery
developer services
# Platforms and toolkits

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Studierstube ES toolkit

- Scene Graph
- Tracking
- GUI
- Multimedia
- Networking

Hardware Abstraction
(Windowing, Rendering, Audio, Video, User Input, File System)

- Middleware Client
- Studierstube Tracker
- Rendering Toolkit
  (OpenGL ES, Direct3D Mobile)

Hardware
(CPU, GPU, Display, Touchscreen, Buttons, Audio, Camera, Wifi, Bluetooth)
Phase One achieved

Part of **smartphone** ecosystem.

Hardware & software **platforms** exist.

**Infrastructure** issues: huge.

**Power use** issues: huge.

**Privacy/security issues**: huge.

**Interoperability** issues: typical.

**But**

Phase One AR is just one aspect of transition to mobile broadband devices as our primary platform.
Augmenting Revenue Now

Immediate value

• Extend existing software to **enterprise mobile, task-assistive** apps

• Build AR into new apps, including web services/DBs

• Extend social networking apps & online worlds/entertainment

• Handheld to desktop screen to projector

• Major brands: marketing extensions
Augmenting Revenue Now

Enterprise mobile applications: Marybeth Back, FX Palo Alto Labs & TCHO

Practical Application
• Maintenance or design history with image and text
• Marker-based or image-based AR
• Viewable on tablet or cellphone
Augmenting Revenue Now

Enterprise mobile applications: Marybeth Back, FX Palo Alto Labs & TCHO

Factory floor AR

Point at specific areas/machines:
• Realtime data from factory control software
  - sensor states
  - control states
  - time-to-service
• Customer & job data
• Actual machine control
• Static info
  - operation procedures
  - maintenance history
  - performance charts
  - overview data
  - unit specifications
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“UbiComp”: Mark Weiser (PARC)

Commercial aviation

Dedicated tools begin:

ARToolkit
UW HITLab

The goal

Commercial helmet-mounted displays

Useful smartphone AR

Efficient power usage

Hands-up displays

Nokia’s MARA

Sutherland/Sproull, ‘68: 1st HMDs

Tom Caudell & David Mizell
**Mark Weiser** (1952-1999)
Mathematician, philosopher & first ubiquitous computing theorist

1: The purpose of a computer is to help you do something else.

2: The best computer is a quiet, invisible servant.

3: The more you can do by intuition the smarter you are; the computer should extend your *unconscious*.

http://sandbox.parc.com/hypertext/weiser/
Next Steps: AR Phase Two

“It’s all about long-term, sustaining relationships.”

- Alan Kay (2009), on the computer industry trend toward a service-based model.

• Phase Two delivers value if we have long-term, sustaining, contextually dynamic, hyperpersonalized relationships between users & info services.

• The available data streams must be far better managed.

...It will just happen first on smartphones.
AR Phase Two

Adaptively deliver info, highly personalized via n dimensions of user states, with high space/time precision, *without* spiking your cognitive load.

Augmented Context + Information Salience = Value
Smartphone AR Phase Two

Smartphone ecosystem:

The platform for:

- Pervasive computing
- Context-awareness
- Semantic Web
- Ubicomp & sensor nets
- Ambient Intelligence
- Things that Think

...at last.
Smartphone AR Phase Two

Mobility
  • Diversity of use cases per user.
  • User attention: scarce resource.
    ➞ Tool should learn the user.

The learning is contextual: context becomes king.
  • Location + user’s path in space, time, tasks, people...
  • Accretes
  • Becomes predictive, scenario-driven.

Result: Adaptive context analysis manages data delivery:
  what, when, how much, what priority.
    ➞ Especially when not to.
Phase Two

**Context Is King**

Trend to realtime, context-driven mobile broadband services.

“The software layer that learns you.”

Facets:

- Realtime data delivery (live monitoring of processes & states).
- Constant predictive analytics, contextual filtering/salience assessment.
- Your path through space, time, task, data, people, & ...
- Semantic Web: better, more meaningful, partly automated search.
- Hyperpersonalized database creation, web services.
- Sense Networks (NYC)
- Digital assistants (Siri.com) learn you over time.
- Entertainment: “The Character Layer” ...a skin over the functions.
Phase Two Software

- Constant, robust markerless 2D & 3D feature I.D. and object recognition (Nokia Point & Find, Google Goggles ...).
- Motion analysis + evaluation linked to the object recognition.
- General-purpose indoor position mapping: multiple methods.
- More nuanced gestural interpretation + integration with voice.
- Constant audio + visual awareness with flagging & interpretation.
- Allostatic control of data delivery: only the data needed, when needed.
- Constant autodiscovery of data & sensor feeds.
Phase Two Hardware

- Near-field RFID (“touch / wand”)
- Constant, wide-field visual recording + auto-tagging
- Constant markerless object I.D. in 2D & 3D + auto-tagging
- Constant audio recording + auto-tagging
- Galileo-grade location (+ dead reckoning extrapolation)
- Ultrasonic & IR sensors for position sensing, spatial analysis, modeling, mapping, contextualizing
- Laser projector + 3D object geometry awareness: “shape-adaptive projection” for object augmentation
Phase Two Revenue Example

Entertainment

All major licensed characters available on your smartphone as a useful buddy, *running as the delivery method on top of context-aware, locational, hyperpersonalized functions.*

The character behavior, persona, and actual animation: **Character Skin** or **Character Layer**.

An opportunity-rich scenario.
Dubailand AR project, ‘07-‘08

• Convert the concept to smartphone AR

• Live & scripted personalized entertainment via licensed characters, plus services for hotel, leisure, retail, restaurant, transit, and follow visitors home.
Dubailand AR project ‘08
Dubailand AR project ‘08

- Storytelling
- Extension of attractions
- Personal guide/friend
- Contextually customized experiences
- Interaction with park elements
- Wayfinding
- Drill-down for information
- Social networking: local & global
- Database: each user’s interests
- Game play on device & with others
- Marketing: retail opportunities
- Long-Term Relationship: “follow the visitor home”
Phase Two Revenue Example

Health

N-dimensional context-awareness of states of medical procedures, constant salience assessment of those states, plus data streams from a constantly adjusted subset of the hospital’s devices, systems, dispensing & scheduling software, per patient, accreting into realtime patient history, plus staff paths and staff tool usage (also accreting). Constantly perform predictive analytics on the streams of states & data.

- Error Avoidance, detection & correction in routine and acute treatment
- High-trust home care provision systems: reducing hospital bed nights
- Realtime status information delivery, as needed, for each staff member
- Escalation parameter modeling and monitoring
- Services deployment derived from Point Of Care Testing
- Dynamic, adaptive resource allocation
- Assistive management of very large datasets for treatment/diagnosis
Phase Two Model - Consciousness

Some key functions of human consciousness:

1) Constant, integrated analysis & evaluation of surroundings

2) Dynamically judge salience of each aspect of user’s current situation in context of personal goals/needs

3) Constantly construct scenarios for next step: drives info delivery

---

Parallel function of AR2: assess, select & deliver salient data:

- “Contextual evaluation drives contextual augmentation”
- “Software ‘awareness’ augments user’s awareness”

History + current state = basis of decision-making for next state
The brain’s Default Mode Network

- One of the hardest-working systems in the brain
- Active only when the brain is *not focused* on a particular task
- 2 linked brain areas:
  A) Imagination, empathy for *intent* of others, + *state* awareness
  B) Personal *memories* + visualization of future *scenarios*

Phase Two Implementation Model

Scenario modeling

State & intent awareness
Default Mode Network of the brain

Posterior cingulate cortex, with the precuneus: accessing personal memories, visualizing oneself in scenarios

Medial prefrontal cortex: Imagining & modeling the mindset of others.

> Who you are, what’s relevant now, and very-near-future scenarios to choose from
Phase Two Implementation Model

**Brain Default Mode Network** = constantly considers what to do next
  > Observe **states/intents**, visualize **scenarios/outcomes**
  > Scenario creation supports each next **decision**

**Phase Two mobile broadband apps** assess, prioritize, & select data to deliver...to support **decisions**
  • Realtime information mgmt. helps **preserve focus**
  • Inverse Content Management System (CMS) ...the **filter** part
  • Adaptive B2B & B2C service optimization ...the **revenue** part
Phase Two Model - Function
Revenue & efficiency from contextual salience

Location Based Services

Hyper-personalization, relationship mgmt.
Autodiscovery: net services & sensor data
Integrated sensor, gesture, & voice
Predictive analytics

Constant personal scenario support
Phase Two Model - Function
Revenue & efficiency from contextual salience

Location Based Services

- Context awareness.
- Hyper-personalization, relationship mgmt.
- Data interchange standards.
- Autodiscovery: net services & sensor data
- User control of personal data.
- Integrated sensor, gesture, & voice
- Artificial intelligence permeates web svcs.
- Predictive analytics

Constant personal scenario support
Phase Two Model - Function
Revenue & efficiency from contextual salience

Location Based Services

Context awareness.
Hyper-personalization, relationship mgmt.
Activity awareness & modeling.
The opposite of advertising.

Autodiscovery: net services & sensor data
Data interchange standards.
Adaptive filtering of realtime data.
Sensor datastream analytics.

Integrated sensor, gesture, & voice
User control of personal data.
Better interfaces matter.

Predictive analytics
Artificial intelligence permeates web svcs.
Probabilistic data delivery.
Resource conservation.

Constant personal scenario support
Phase Two Model - Function
Revenue & efficiency from contextual salience

Location Based Services

Context awareness.
Hyper-personalization, relationship mgmt.
Activity awareness & modeling.
The opposite of advertising.
Siri, Aloqua, my6sense

Data interchange standards.
Autodiscovery: net services & sensor data
Adaptive filtering of realtime data.
Sensor datastream analytics.
Corventis, Pachube, Sense Networks

User control of personal data.
Integrated sensor, gesture, & voice
Better interfaces matter.
Probabilistic data delivery.
Canesta, Apple, Softkinetic, Nuance

Artificial intelligence permeates web svcs.
Predictive analytics
Resource conservation.
Your Name Here

Constant personal scenario support
Software

Still further out...

Rob Cook’s award talk at Siggraph ‘09:
“...the next holy grail for the computer graphics community should be realism augmented reality.”

http://media.siggraph.org/s2009podcasts/RobCook_AwardExport.mov
AR-related conferences

7th IEEE Workshop on Ubiquitous Communications & Services: www.ubiquitous-management.org/mucs/2010/index.php
IEEE Symposium on 3D User Interfaces (3DUI), March 20-21 2010, Waltham, Mass
http://conferences.computer.org/3dui/3dui2010/
Mobiquitous 2010 www.mobiquitous.org/
5th Int’l Conference on Body Area Networks September (BodyNets) Sept. 10-12, 2010 Corfu, Greece www.bodynets.org/
IMMERSECOM 2010 http://immerscom.org (2009 was at Berkeley)
Location Intelligence Conference 2009 June 2, 2010, Washington, DC www.locationintelligence.net/
3rd Int’l Conference on Mobile Ubiquitous Computing, Systems, Services & Technologies UBICOMM October 11-16, 2009 -
in Sliema, Malta www.iaria.org/conferences2009/UBICOMM09.html
In’tl Symposium on Wearable Computers (ISWC’10), Seoul, Korea, October 2010. www.iswc.net/iswc10/inc_html/
Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) Orlando, FL www.iitsec.org
Credits

• “iLamps: Geometrically Aware and Self-Configuring Projectors,” Rascar, et al. 2003
• Commercial aviation HUD image courtesy Todd Lapin, cc
• MARA image courtesy Nokia Research
• Handheld AR.net (http://handheldar.net/stbes.php) for Studierstube ES diagram
• Fighter jet HUD device image cc www.rochesteravionicarchives.co.uk
• Photo of sail’s tell-tales courtesy Bill Gracey, cc
• Modern helmet-mounted see-through display courtesy Rockwell-Collins: "SIM EYE SR100-A"
• Photo of Ray Harroun’s Marmon Wasp racecar with mirror, cc The359
• Vuzix Wrap 920AV and Tac-Eye GMD images c. Vuzix Inc.
• Theme park illustrations © Chimera Design, 2007-2009
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• Photo of Alfred North Whitehead from Wikipedia.org
• Photo of Mark Weiser from the PARC memorial page.
• Photo of BMW E60 HUD by Sebastian Klein
  http://commons.wikimedia.org/wiki/File:E60hud.JPG