**The Future of Human-Computer Interaction:** Linking Physical, Digital, and Social Worlds

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**Dcog HCI Lab:** Distributed Cognition and Human Computer Interaction Lab  [http://hci.ucsd.edu](http://hci.ucsd.edu)

- Analyzing Activity Dynamics
- Pad++ & Dynapad: Multiscale Personal Information Environments
- Automation in Commercial Aircraft
- Ethnography of Driving
- Paper Augmented Digital Documents
- Negotiated Access
- Campus of the Future
- Rufae: Augmented Environments
- Embodied Interaction and Gesture
Computers Are Special

*Computers are special in that they provide a new kind of stuff out of which to fashion dynamic interactive systems to assist thought, communication, collaboration, and action.*

Computation provides the most plastic medium for representation, interaction, and communication we have ever known:

- Mimic existing media (e.g., books, newspapers, magazines, photographs, audio recordings, and films)
- Create new media and modify the form of existing media,
- Create models that represent, with ever increasing fidelity, the physical world
- Provide virtual worlds that range from the simple metaphorical desktop of the graphical user interface to the amazing digital effects and virtual characters of current games and films
- Combine the real and the virtual, as with computer-augmented surgery in which images of internal structure are projected onto a patient’s body to guide surgery and robotic-assisted controls remove the tremors from the surgeon’s hands

“The computer is the first metamedium, and as such it has degrees of freedom for representation and expression never before encountered and as yet barely investigated.” -- Alan Kay

Morphable Model

A Morphable Model for the Synthesis of 3D Faces

Volker Blanz
Thomas Vetter
Max Planck Institute for Biological Cybernetics
**Morphing Ethnicity**

Slowly, almost imperceptibly, the face of the artist transforms continuously into his Asian or African counterpart. This counterpart is a synthetic version of his own face with everything changed that is specific to ethnicity, but everything retained that sets him apart from the average white male.

The technology behind this work is an average face generated from 3D scans. The average faces and all original faces can be thought of as points in a high-dimensional *Face Space*.

Differences between ethnic averages describe what is typical to ethnicity. Adding them to a face affects only the perceived ethnicity, yet leaves all unrelated features unchanged.

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**Seam Carving for Context-Aware Image Resizing**

*Siggraph 2007*

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Shai Avidan  
Mitsubishi Electric Research Lab  
Ariel Shamir  
The interdisciplinary Center & MERL
FTIR: Multitouch

Visionmaker Desk
Microsoft Surface

IBM: The Everywhere Displays Project
Today’s Context

Rapidly changing technological landscape
- Unbundling of the monolithic computer
- Power and ubiquity of computing
- Tremendous challenges and opportunities
- Boundaries between physical, digital, and social worlds are increasingly permeable (for good and for ill)

Not just the desktop computer any more
- Increasingly we have multiple and we don’t think of many of them as computers
- Connected to computers, sensors, and people all over the world
- Web is changing our professional, personal, and social lives
World Wide Web

Exciting times:
- Web 1990
- Mosaic browser 1994
- Yahoo! 1994
- eBay 1995
- Google 1998
- Wikipedia 2001
- MySpace 2003
- Second Life 2003
- Web 2.0 2004
- Facebook 2004
- flickr 2004
- World of Warcraft 2004
- YouTube 2005

Exciting Time for HCI
Tremendous Challenges and Opportunities for Design and Research
Augmented Surfaces, Rekimoto ‘99

Big Idea: Linking Physical, Digital, and Social Worlds
- Weiser: Ubicomp and Calm Technology
- Ishii: Tangible Media. Giving physical form to digital information and computation, making bits directly manipulable and perceptible.
- Key importance of cognitive science: understanding people and social context of everyday activities

Plan

- Bridging Paper and Digital: One important example
- A Little History
  - Ideas have histories
  - Very important to know their histories
- Current Research Systems
  - PADD and PapierCraft
  - ButterflyNet
- Interesting Forthcoming Commercial System: Livescribe

The Myth of the Paperless Office, Abi Sellen and Richard Harper
The most well-known
- Xerox Star and the ethernet would make for paperlessness

But paper persisted
- Because digital did not afford the same possibilities
- It acted as a tangible, universal network
- As a work-around for bad system design

Through HTML
- Networks were opened up (who needs paper?)
- New document forms (who needs paper?)

But paper persisted
- Because digital still did not afford the same possibilities

Worse-more paper was produced
- Because people downloaded more to read
Tablets

Tablets
- Wireless: away from the desktop
- Pen-based interaction (who needs paper?)
- Annotation, editing, note-taking (who needs paper?)

But paper persisted
- Because digital did still not afford the same possibilities
- And tablets not quite good enough
  - Heavy
  - Unreliable
  - Batteries limited

Digital Paper

Are new augmented papers going to do away with paper?
- Attacking paper by making paper a computer that combines:
  - Paper affordances
    - To read as if on paper
    - To navigate as if on paper
    - To annotate as if on paper
  - Computer affordances
    - To edit as if on a computer
    - To create as if on a computer
    - To save, store, and access as if on a computer
Alternative Approaches

Is there a solution to the digital-paper divide?

- One approach is to try to make one or other technology subsume all the other can do
- Another approach is to try to link them in ways that give us the best of both
Pen Technology

Anoto
- Pen camera uses IR LED light
- Pattern is printed using IR absorbing inks
- User content must be printed with IR transparent ink
  - C, M, Y are IR transparent
  - Black should be printed as C+M+Y not K

Pens
- Logitech, Nokia, Maxell, ...

Records
- Stroke coordinates (X, Y, relative to page)
- Page ID
- Pressure
- Time stamped (realtime clock)
- 50–100 images / sec
- Potential to read barcodes

Communication
- USB
- Bluetooth

Pattern is
- Large address space
- Time consuming to print
  - Use pre-printed paper
  - Use new fast (but expensive) color printer

Other technologies
- Datablytics [Hecht 94]
- MEMO pen [Nabeshima 95]
- Others

From Anoto documentation

Cohabitation

Digital World
Print on paper with digital pattern

Paper Augmented
Digital Document

Paper World

Merge pen strokes to document

Navigate, Annotate, Discuss

Edit, Search, Share, Archive
PADD Acrobat plug-in

PADD: detail 1

Original text from the Economist
ProofRite
Dave Levin and Kevin Conroy

Integrating proofreading and word processing
- Implemented on top of AbiWord

Digital World

Paper Augmentation System

Paper World

The brown fox jumps over the lazy dog.

The brown fox jumps over the lazy dog.

The brown fox jumps over the lazy dog.

The brown fox jumps over the lazy dog.

The brown fox jumps over the lazy dog.

A First Prototype

Digital versions of annotated PDF’s

Annotation benefits: what you don’t have to say, context

Help manage attention and harvest intent

PenHance Prototype, Rod Ebrahimi and Jim Hollan, UCSD
In collaboration with François Guimbretière, University of Maryland

www.dotherightthing.com
Rank companies by impact and whether doing the right thing

Cogsci 120: Human Computer Interaction
**Simple annotations are not enough**

Reference article  
Reference to notes  
Excerpt text  
Collage  
Excerpt graph

**PapierCraft**

Liao, Guimbretière, Hinckley, and Hollan,  
Commands in PapierCraft

Scope + Pigtail delimiter + Marking menu

Scopes

Figure 4: A possible implementation of the stroke collector inspired by an author's proposed architecture. From left to right: the stroke collector retrieves the strokes from the pen, as well as the page ID on which they were created. The Stroke Collector retrieves the name of the document database managing this page ID using the Paper Look-up Service. It can then contact the database directly to merge the imported strokes with the PADD.
### Basic commands

**Excretion**

**Hyper-linking**

**Stitching**

### Complex commands

**Naming command**

**Tagging**

**Triggering actions**

- Google
- E-mail
Many domains, including design, biology, and architecture, do not view computers as their primary tools.

ButterflyNet: Ron Yeh

Combine Anoto Pens & Notebooks
  - Support Existing Practices
  - Graceful Degradation in the Field
    The biologist is NEVER worse off than just using regular pen and paper.
The biologist captures photos and notes as he normally does. The content is automatically associated by the timestamps in the pen and photographs (JPEGs).

Notes + Photos associated by **time**
Alternatively, he may take a photo, and draw a box in his notes. This photograph later appears “embedded” in digitized notes.

Notes + Photos associated by Inked Gesture (Hotspot Gestures)

ButterflyNet Browser

This is the digital browser. As the user flips back and forth in the notes, the photos are automatically updated to show the content MOST related to the current notes. The next several slides show an animation of what this looks like to the user.
Navigate by Pen

Browse using the Physical Notebook

The pen talk to your computer in real-time. If the biologist taps on his notes, ButterflyNet can flip to the right page. Thus, you can search by using the physical artifact.

Jim Marggraff, CEO
Why do so few people make significant contributions?
- Is it luck?
- What is the difference between those who do and those who might have done?
- If you think you can’t almost certainly you won’t

Why not do significant things and really first class work?

Prepare yourself
- Time to start is now
- Do what you love and learn to love what you do
- Don’t worry how intrinsically smart you are or anyone else is
- To do significant things you have to neglect other things
- Be careful about commitments but when you commit really do it
- Take time to think important thoughts
- Be especially careful about who you spend time with