

COMPUTING VISIONS 2025:

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MAJA MATARIC (USC)



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Genesis Vision 2025

- Nov. 2012: AD Farnam Jahanian engaged CISE Advisory Council in a brainstorming around CISE 10-15 years out
- Feb 2013 CISE AC Chairs for a Vision 2025 WG
 - Culler, Landay (chairs), Fran Berman, Jaime Carbonell, Teresa Dahlberg, José Fortes, Juan Gilbert, Peter Lee, Stefan Savage, Bobby Schnabel
 - 3 meetings in preparation for a May 2013 breakout
 - Brainstorming, Major Thrusts, NSF implications
- May 2013 Breakout Session and Discussion
 - Compelling experience led to a desire to engage the community more broadly
 - => Joint CCC/AC committee to produce an integrated suite of workshops offering different perspectives on common question.

The May 2013 Tee up

The Charge

- Where is the field going over the next 10-15 years and what should NSF CISE do in response?

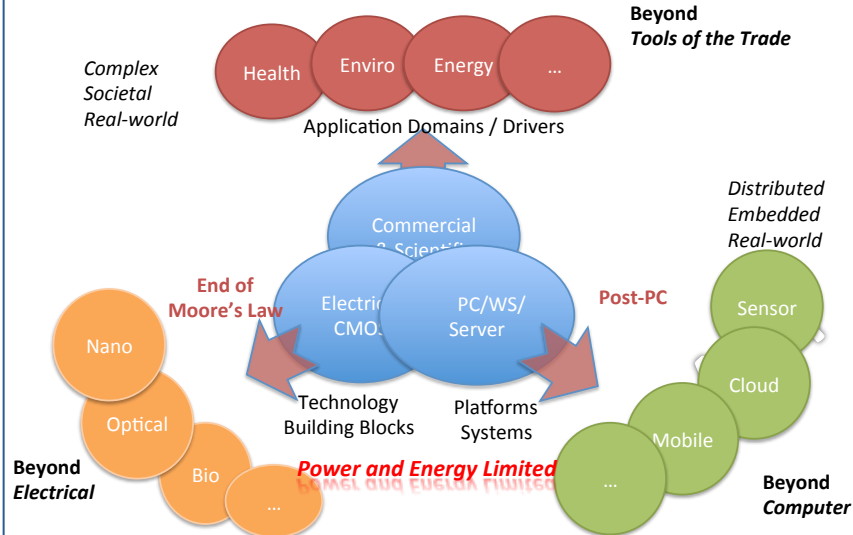
Underlying Questions for WG

- Why is looking out 10-15 likely to be even more important now?
 - Major transformations in the landscape?
 - “new renaissance”
- What might it all mean for CISE?
 - Three Themes: indy mfg, post mobile, massively connected society
- What we should be doing about it?
 - White paper(s) ???
 - Multiple viz stmts => retreat => actions study
 - Organizational examination

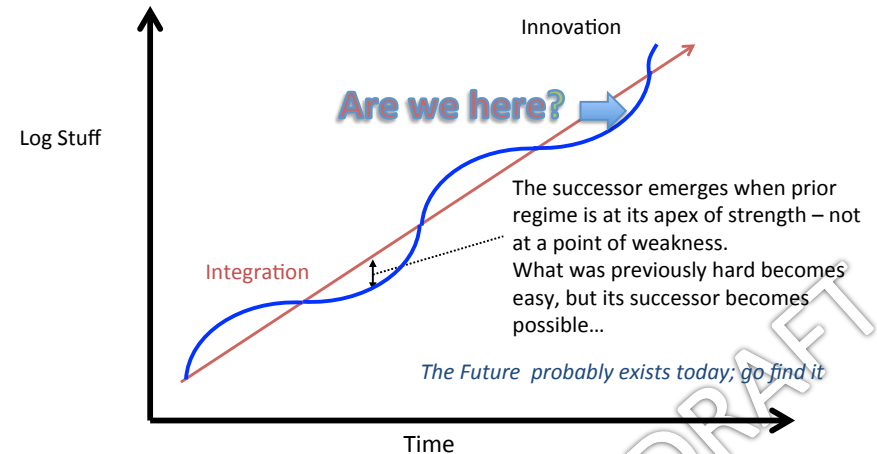
DRAFT

NSF AC WG

The Three Legs of CISE “sweetspot” Transformed



Tides of Innovation



A New Renaissance

- The Information Age has transformed the world as we know it. (is transforming?)
- Now that digital technologies are fundamentally integrated in virtually every aspect of modern life, what does the “new” Renaissance circa 2025 promise?

Renaissance

... cultural movement sandwiched between the dark ages and the industrial revolution giving rise to modern science, culture and politics...



Enabled by the invention of movable type - sped the dissemination of ideas...

Three Cross-cutting Thrusts

- Indy Manufacturing
 - Pervasive innovation, mass customization, creation of goods and services by individuals with wide distribution, possibly highly specialized, open source copy-paste & edit things like SW is today
- Post mobile
 - Programmable intelligence all around us, within us, and between us
- Massively connected society
 - Expansion of the social contract, cyber-enabled organizations, democratization of education and research

WHY VISION 2025?

There is a sense in many different parts of the community that we are on the cusp of transformational changes that make looking out a decade from now very different than such exercises in the past

- Not just technological change, but societal change and individual change
- Need to get beyond our disciplinary and sub-disciplinary silos to grasp it fully

CCC/NSF CISE are brainstorming on this common question from several different perspectives in three partially overlapping workshops

THREE WORKSHOPS

Interacting With the Computers All Around Us

When disruptive technology transformations change our interaction assumptions: how will these change interactions of people to computing, machine to machine, & people to people?

The New Making Renaissance: Programmable Matter and Things

When the decentralization of creation and mass delivery of software is achieved for many other constructive arts: 3D printing, synthetic biology, printable electronics, end-user programming, manufacturing, robotics, design, health, CAD/CAM, & intellectual property

Computing & the Smart World

When “smart everything” will trigger major transformation in societal services: health, education, transportation, & more

Some overlap among topics and participants in very different settings
Build comprehensive 2025 vision from the outcomes of the workshops

COMPUTING VISIONS 2025: INTERACTING WITH THE COMPUTERS ALL AROUND US

MAY 13, 2014

LIMOR FIX, JENNIFER REXFORD, DANIELA RUS
WS CHAIRS

CCC/NSF sponsored workshop



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WORKSHOP GOALS

Develop visions and identify core technologies needed for the future of **interaction among humans, computers, and the physical world**:

- ***Assist people:*** Health, Education, Work, Family, Home,...
- ***Empower communities:*** Communicate, collaborate, organize for better sustainability, quality of life, ...



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PARTICIPANTS

- Session chairs: Andrew Senior (Google), Vijay Kumar (UPenn), Seth Teller (MIT), Maja Mataric (USC)
- Around 50 participants: top universities, NSF, DARPA, Navy, Air Force, Army, IBM, Google



Seth Teller - dear friend and colleague

INTELLIGENT ASSISTANTS

- In 2025 we expect computing to dramatically improve the way it assist humans in three fundamental activities:
 - Cognitive, Physical, Social
- A vast variety of **Networked Intelligent Assistants** will exist
- Assist humans to overcome challenges in education, health, elder-care, population growth, work, sustainability, and more



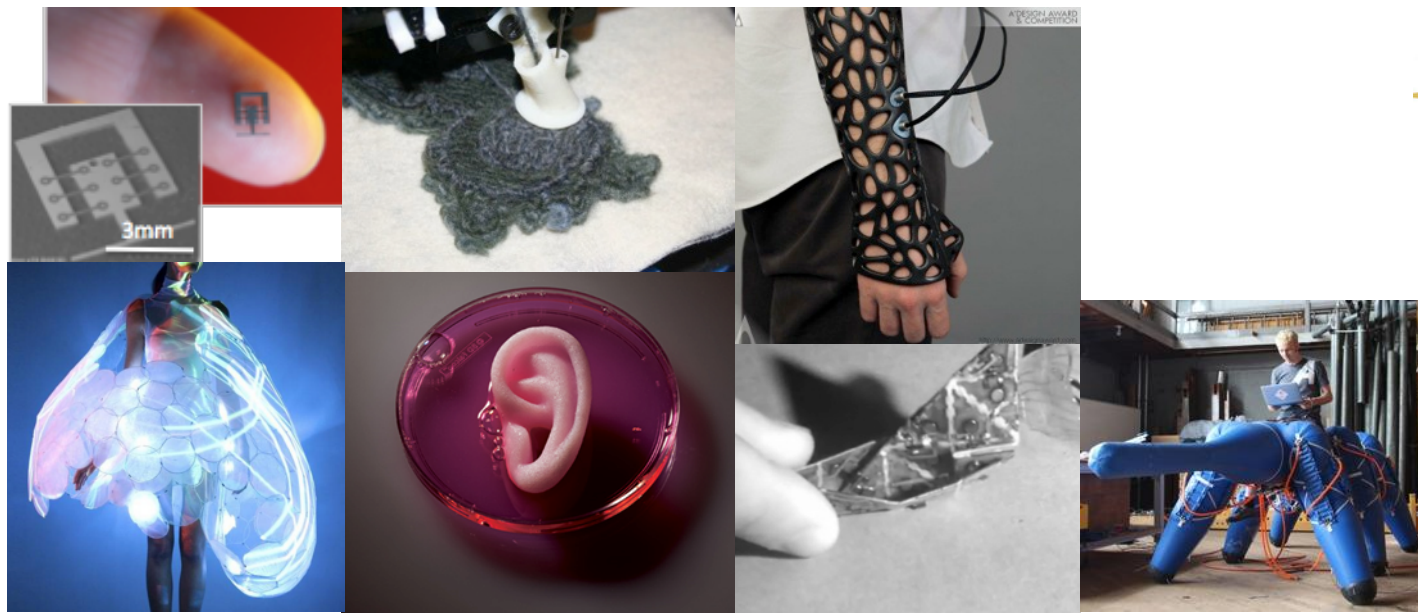
CONCLUSIONS

- Many computational fundamentals come up in multiple application areas
 - user understanding, natural interfaces, multi-modal/fusion, multi-party, connectivity, real time, vast amount of data, trust
- Great benefits in cross-pollination within our rather vast computational research world (not only between computation and other areas/cross-disciplinary)



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THE NEW MAKING RENAISSANCE

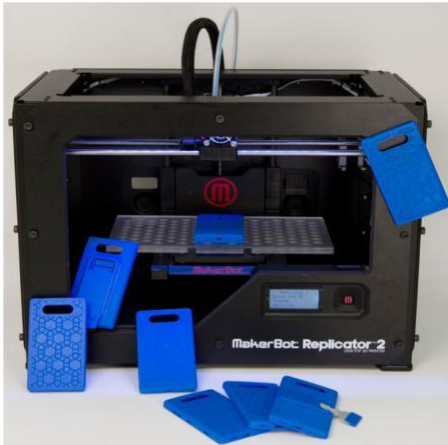
Programmable Matter and Things

NSF / CRA Vision 2025 Vision Workshop
held 2-4 June 2014

Eric Paulos, UC Berkeley
Prabal Dutta, University of Michigan

David Culler, UC Berkeley
James Landay, Cornell Tech / Stanford

NEW MAKING RENAISSANCE: A REVOLUTION?



DIGITAL
FABRICATION

+



FLEXIBLE
ELECTRONICS

+



UBIQUITOUS
PROGRAMMING

This new renaissance, underpinned by “maker movement”, may change the way that most items are designed, manufactured, and delivered.

Confluence of 3 major trends:

- cheap and fast creation of matter in new forms (e.g., 3D printing)*
- on-demand electronics*
- programmable intelligence in every object*

The creativity & change unleashed could change how society operates: return to craftsmanship with precision and the ability to mass customize/produce.

46 PARTICIPANTS • 2 DAYS • 3 KEYNOTES



WOMEN & MEN REPRESENTING

Academia

Industry

Entrepreneurs

Technology Leaders

Scientists

Sociologists

Designers

Artists

Government

NSF / CRA

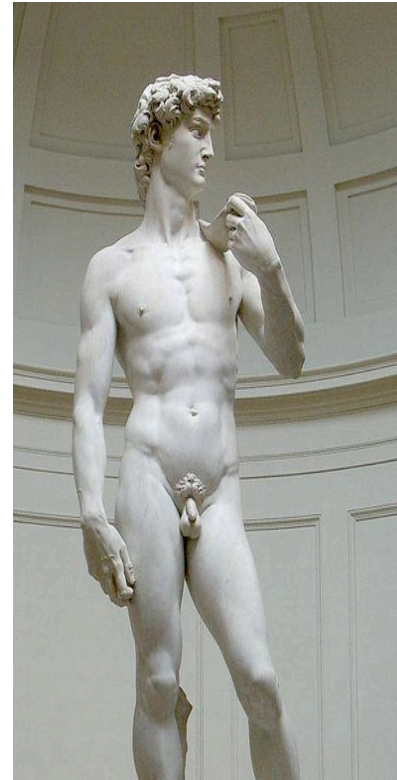
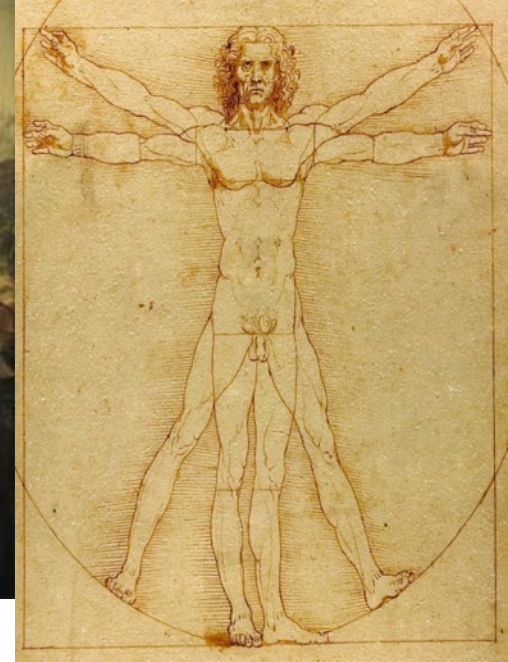
Across a range of disciplines



WHY RENAISSANCE?

Drawing inspiration from
the historical rebirth
movement across

ART
+
SCIENCE
+
CULTURE



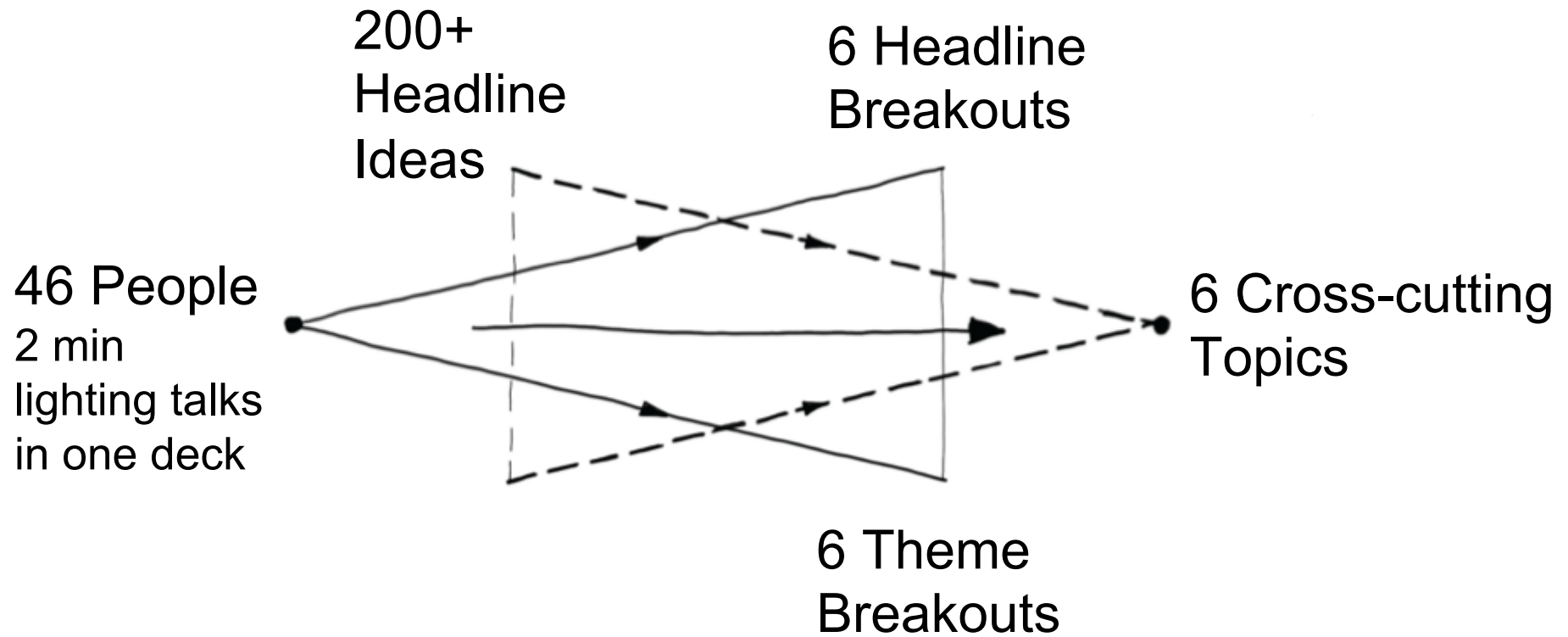
SOCIETY HAS BEEN HERE BEFORE



EARLY 1800'S MECHANICAL PROGRAMMING
REVOLUTIONIZES HOW THINGS ARE MADE

FAMILIAR ISSUES RESURFACE:
SAFETY, LIABILITY, STRUCTURE OF LABOR

WORKSHOP FORMAT



LIGHTNING INTRODUCTIONS

2 MINUTES
2 SLIDES

Who are you?
What do you do?

What is the primary
Opportunity
Challenge
Open Question
in next 10-20 years





HEADLINE BREAKOUT GROUPS



TOP HEADLINE TOPICS

Robot Termite Builders

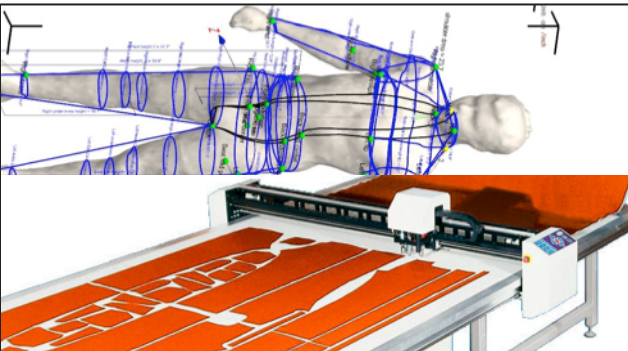
Genetic Algorithm Wins Furniture Competition

Bespoke Digital Tailors

Spinal Column Grows with Child

Internet of Things Fatigue

Bioluminescent Trees



EMERGING THEMES BREAKOUT GROUPS



Interplay of Science and Design

Education and Training of Makers



Design Tools

Empowering Small Business



Health and Bio

Sustainable Infrastructure Meets Making

KEY CROSSCUTTING TOPICS

Science, Education & Design are Intertwined

- come at solutions differently, but all are required for innovation
- just-in-time, lifelong learning & project-based learning key
- where does higher ed fit in this?

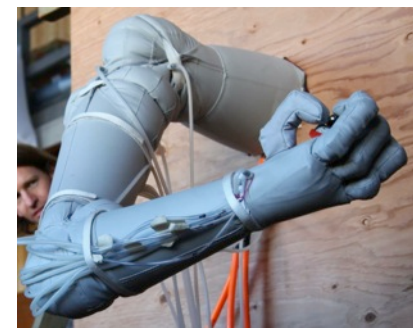
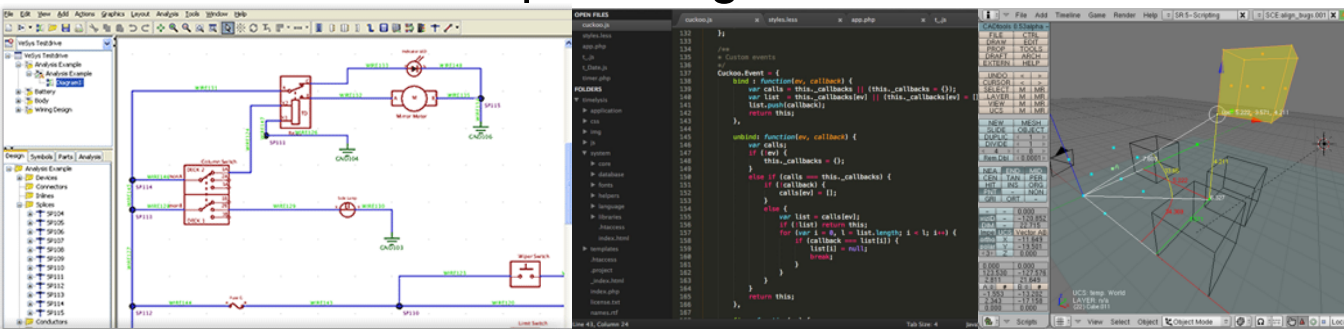


<http://bouncingideas.wordpress.com/2011/11/12/design-engineering-science-their-differences-through-the-lens-of-biomimicry/>



Design Tools are essential to accelerating innovation & productivity

- tools must work across electronics, physical form & software
- need tools to promote creativity
- need tools to help leverage new materials



KEY CROSSCUTTING TOPICS

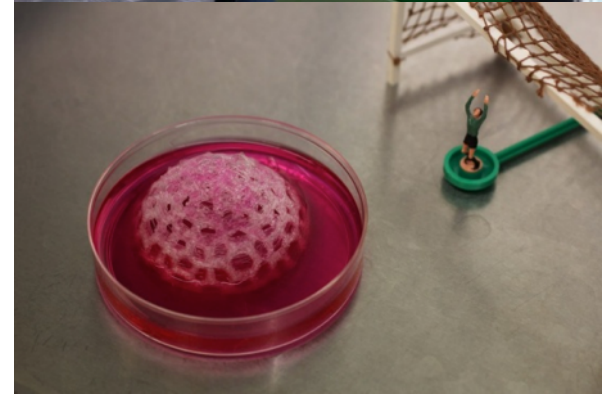
Micro-manufacturing that scales from small to large to empower small businesses

Sustainable infrastructure is necessary

- maker outputs that are recyclable & reusable
- how to augment the natural world?

Health/Bio applications need modular devices

- interface w/ bio parts
- “bio foundries”
- *abstraction barriers* allow designers to focus on their area of expertise
- shape changing implants



CALL TO ACTION

Success of New Making Renaissance requires

Interdisciplinary efforts across practitioners, materials, techniques

Demand **educational** models that promote interdisciplinary thinking and problem solving – a genuine degree in “making”

Foster research that explores across materials and methods (bio | mechanical | electrical | computational) – **hybrid making**

Develop an open a political **regulatory** committee to advise government and public on legal and ethical issues

Broaden **funding** model to support long and short term efforts focused on new making materials and techniques

Capture the energy and passion of this movement by involving local **communities** in problem solving and innovation efforts

THANK YOU



Adobe

Microsoft®
Research



SPECIAL THANKS

NSF CISE AC / CCC: David Culler, James Landay, and Beth Mynatt

CRA: Ann Drobins and Helen Vassaly

COMPUTING VISIONS 2025: AN INITIAL SYNTHESIS



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FOUNDATIONS

- Sensing, recognition and modeling of the external world; fusion
- Self organizing and self-adapting networked objects
- Real-time systems; reliability
- Local and cloud data and computation; security
- Human computer interaction, natural interfaces, long-term adaptive systems



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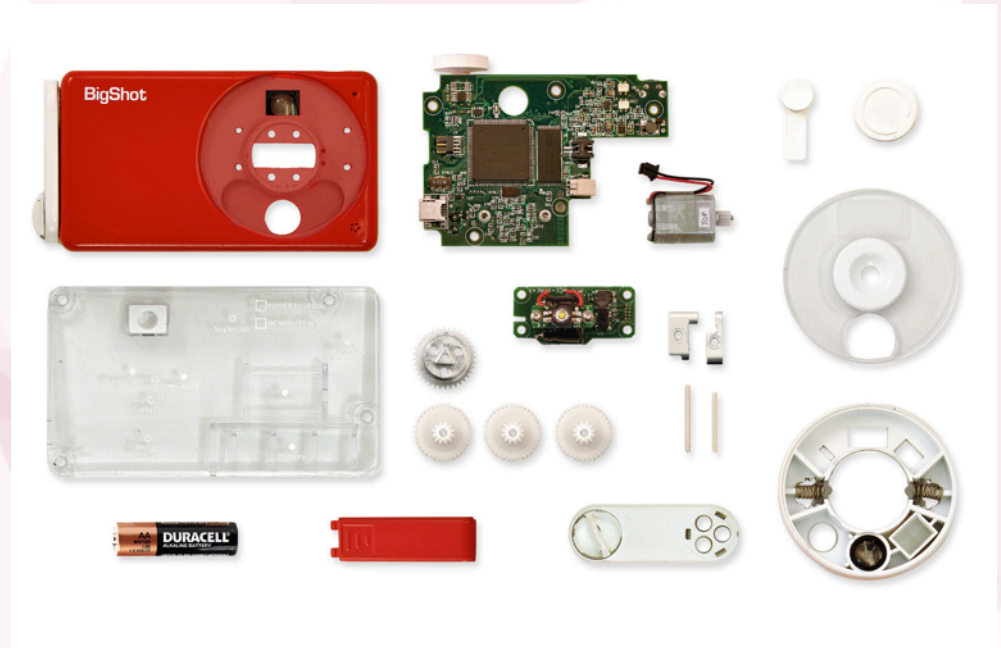
USE INSPIRED RESEARCH

- Assistive technology to Extra-Ordinary human capabilities
- Locally fabricated objects with deep contextual understanding
- RASP: Robots, Agents, Sensors and People
- Shape our physical surroundings
- *What is the app store for the Internet of Things?*



COMPUTING COMMUNITY

- CS Education for computing in the physical world
- Multi-disciplinary research
 - Design community
 - Material science
 - Deep collaborations about use context



Big Shot: The Camera for Education
Shree Nayer, Columbia University



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NATIONAL PRIORITIES

- Aging in place; health caretakers
- Education and employment
- Environmental sustainability



Robot caregiver
Charlie Kemp, Georgia Tech



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OPEN FOR DISCUSSION

- Can we see the cusp of a new renaissance?
- Are these times of great change and opportunity, even reaching a crossroads for the field?
- How do we prepare our research community?
 - How do we train our students?
- How does our research community help address larger societal needs and opportunities?
- What are the implications of technical tradeoffs (e.g. reliance on cloud computing)?



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CCC DISCUSSION

- Ideas for future 2025 workshops.
On the drawing board “Data analytics for a Smart World”
- White papers akin to Big Data papers?
- How to connect to the larger computing community?
- How to connect outside the larger computing community?



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BACKUP SLIDES

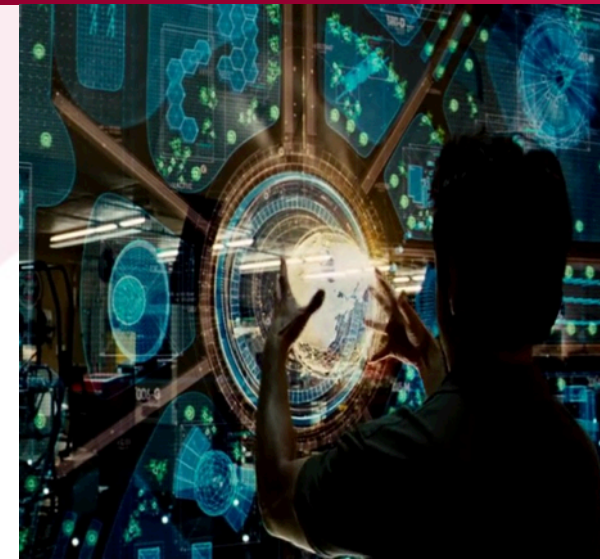


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COGNITIVE INTELLIGENT ASSISTANTS

- In recent years, “digital assistant”, like Siri, Google Now and Cortana
- In the future, we expect such assistants to grow dramatically in their capabilities: tutors/education, decision making, health monitoring/analysis,...
- Capabilities: natural interactions, real-time analysis, access to the cloud and vast amount of data
- Core technologies: sensors, recognition (speech, vision, environment), end-user modeling (user preferences, user special needs), fusion



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PHYSICAL INTELLIGENT ASSISTANTS

- In recent years, co-robots for assisting humans in applications ranging from manufacturing to surgery
- In the future, we expect human-robot teams act seamlessly with natural interfaces, anticipating and complementing each other
- Capabilities: physical augmentation, natural interaction/clarification, high-level (functional) specifications, trust
- Core technologies: 3d perception, manipulation, interfaces, modeling, planning/transparency



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SOCIAL INTELLIGENT ASSISTANTS

- In recent years, “behavior change technologies” have emerged, like the Fitbit, Jawbone, etc. to track, report, and nudge the user's state
- In the future, we expect such assistants to be personalized, interactive and adaptive to relate to each user's evolving needs.
- Capabilities: interpret the user's health and emotional state, understand ongoing and intended activity, provide advice, coaching, and motivation, trust
- Core technologies: integration of multi-modal personal data, working with small-n single-person intermittent data, adaptation over the long timescale from noisy data, personality, motivation



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NETWORKED INTELLIGENT ASSISTANTS

- In recent years, dramatic grows of #devices connected to the internet
- In the future, we expect intelligent assistants of many shapes and capabilities will be part of large smart networked systems with Robots, Agents Sensors and People (RASP)
- Capabilities: swarms, interactions between networked people and machines
- Core technologies: local and cloud data and computation, autonomous machines, reliability, self organizing, self-adapting architectures, real time systems



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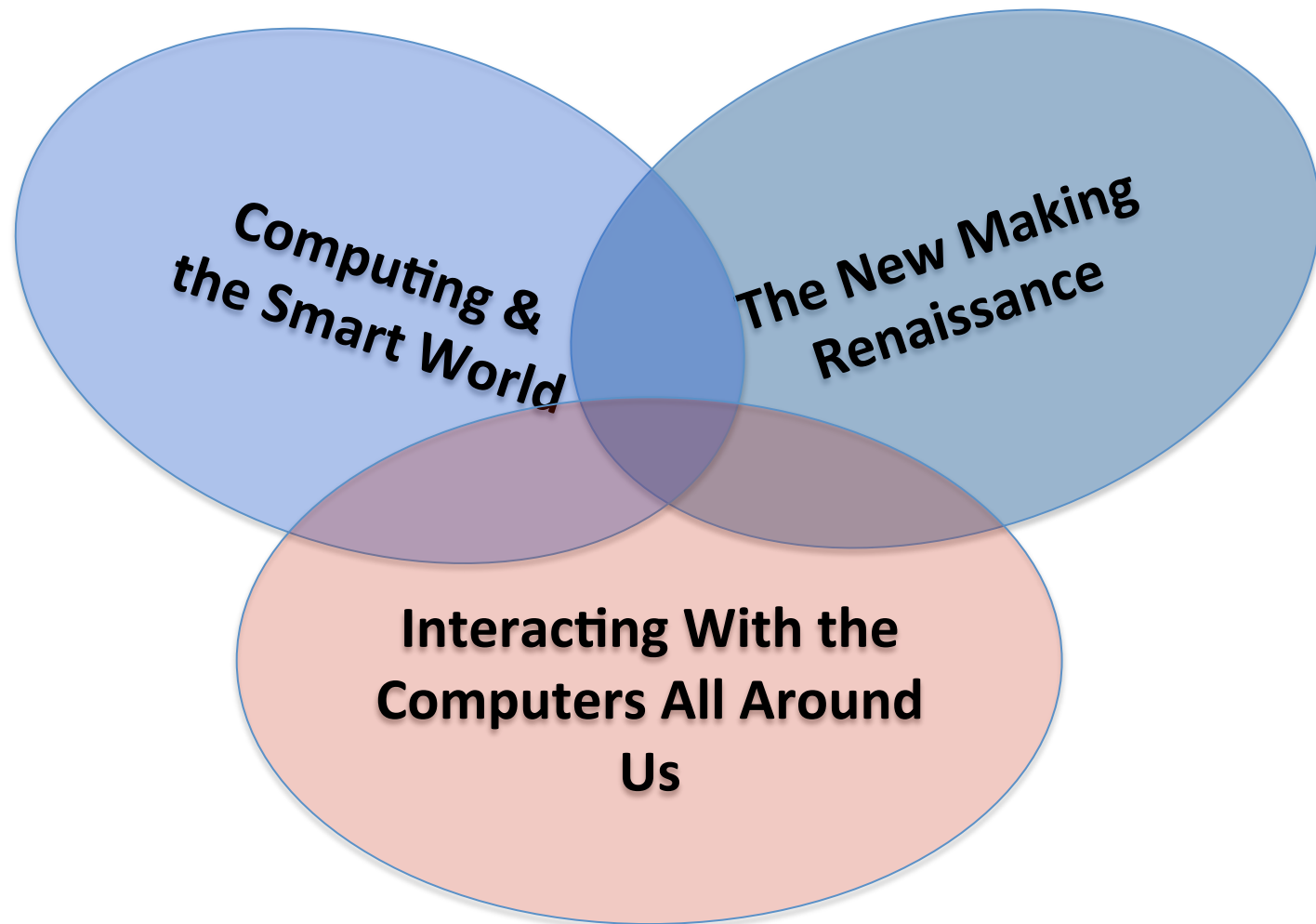
- How come it's not my area X ????



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VISION 2025 WORKSHOP SUITE



GOALS



ARTIFACTS FOR POLICY MAKERS



COMMUNITY & DIRECTION

AREA CLUSTERS

HEALTH

FOOD

BUSINESS

SECURITY

POLICY

CRIME

ENVIRONMENT

EDUCATION

SUPER HUMANS

ROBOTS

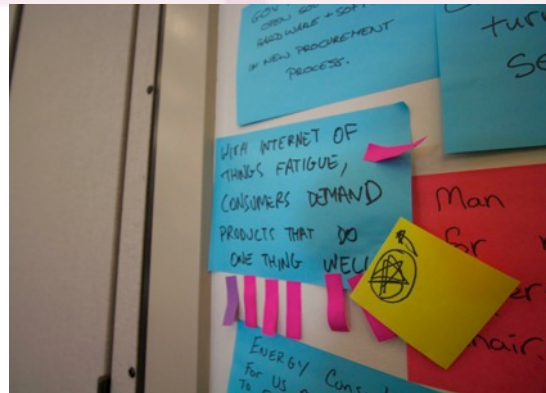
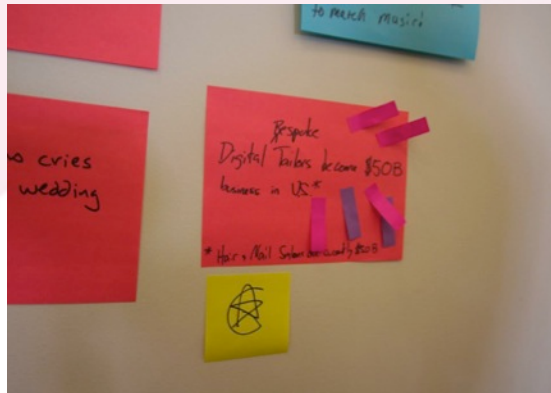
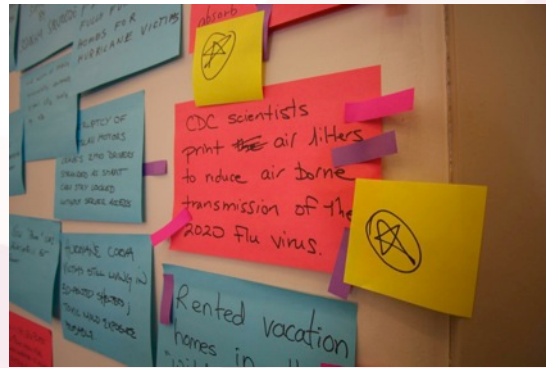
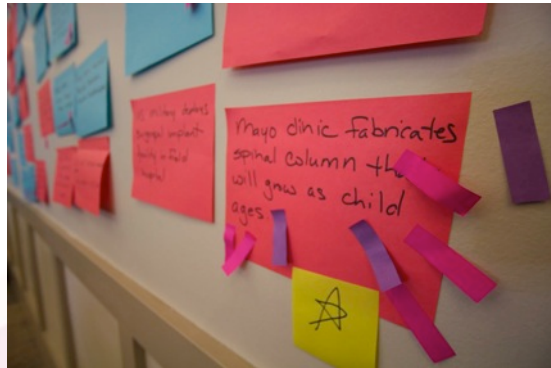
CYBORG / BIO

FASHION

ART

FAIL

FUTURE HEADLINES ... 15-20 YEARS OUT



200+ IDEAS

**6 BREAKOUT GROUPS
DISCUSSED TOP IDEAS WITH
FOCUS ON:**

RESEARCH ENABLERS

TECH INNOVATIONS

NEW BUSINESS MODELS

EMERGING PRODUCTS

SOCIAL IMPACTS

POLICY CHANGES

LEGAL DEVELOPMENTS

OPPORTUNITIES



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