COMPUTING VISIONS 2025:

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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
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?

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
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,…
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)
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
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

46 People
2 min lighting talks in one deck

200+ Headline Ideas

6 Headline Breakouts

6 Theme Breakouts

6 Cross-cutting Topics
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

The Maker

Home Whisperers a Hit
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?

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

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
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
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
NATIONAL PRIORITIES

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

Robot caregiver
Charlie Kemp, Georgia Tech
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)?
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?
BACKUP SLIDES
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
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
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
NETWORKED INTELLIGENT ASSISTANTS

• In recent years, dramatic growth 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
• How come it’s not my area X ????
VISION 2025 WORKSHOP SUITE

- Computing & the Smart World
- The New Making Renaissance
- Interacting With the Computers All Around Us
GOALS

ARTIFACTS FOR POLICY MAKERS

COMMUNITY & DIRECTION
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