Georgia Tech Institute for People and Technology

Augmenting Intellect through Wearables and Artificial Intelligence

Professor Thad Starner
Contextual Computing Group
Georgia Institute of Technology

Tech Lead/Manager, Google Glass

Paths to Augmenting Intellect

- Networked human minds
- Artificial Intelligence
- Augmented Intelligence

Larry Page & Sergey Brin

- Reduce the time between intention and action.

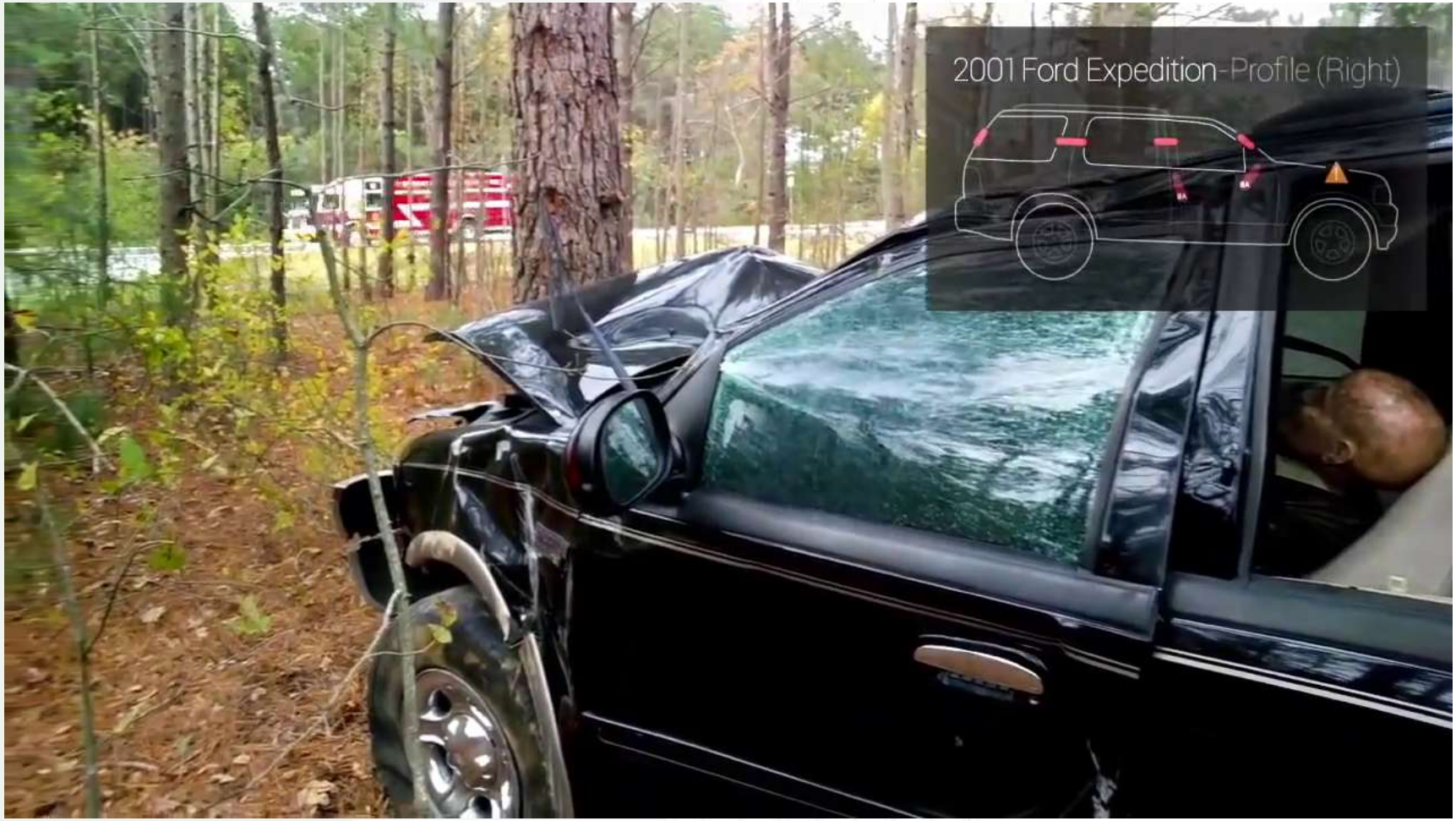
Providing Better Care

Providing Better Care

Improving Job Training

Improving Job Training

Improving Access to Information: Extraction Diagram



Improving Access to Information: Navigation

Improving Communication: Speech Translation

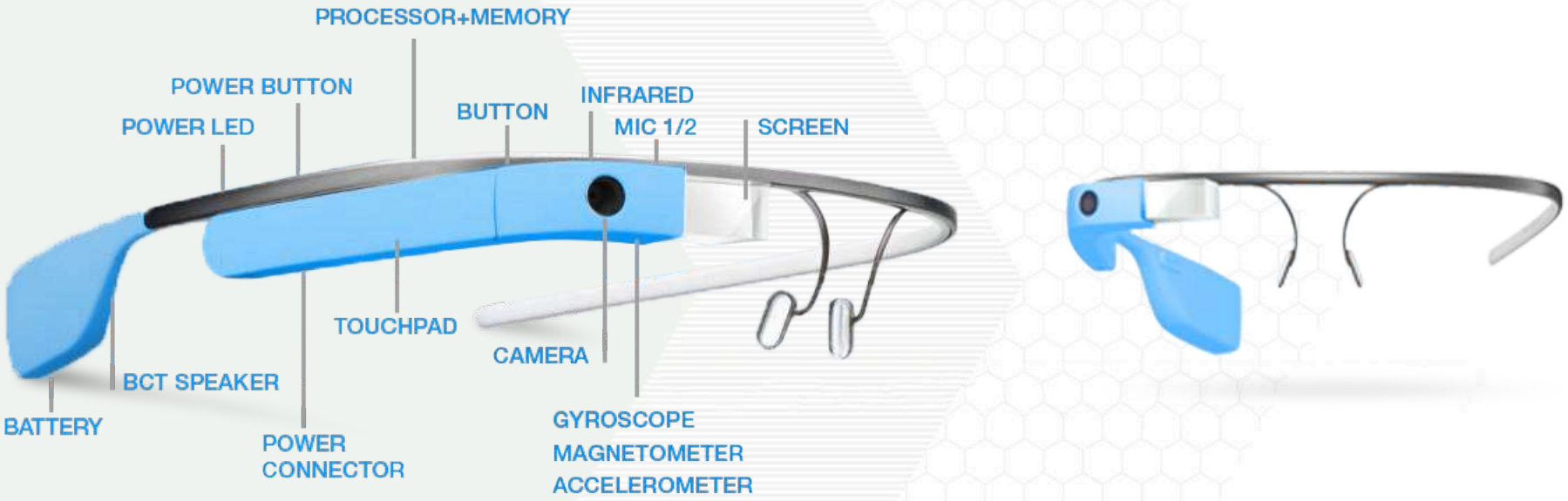
Improving Communication: Speech Translation

Improving Communication: Text Translation

Improving Communication: Remote Expert

Improving Communication: Transcription for Hard of Hearing

Reducing Disability


PROCESSOR+MEMORY
POWER BUTTON
POWER LED
BUTTON
INFRARED
MIC 1/2
SCREEN
TOUCHPAD
CAMERA
BCT SPEAKER
BATTERY
POWER CONNECTOR
GYROSCOPE
MAGNETOMETER
ACCELEROMETER

Why Now?

- **Bluetooth 4.0 Low Energy body network standard on mobile phones starting 2013-now**
- **Available, high quality mobile speech recognition ~2010**
- Low latency cellular network ~2008: LTE/HSPDA
- Windows interface monopoly broken by smartphones ~2008
- **High sensitivity GPS ~2007**
- Quality plastic optics ~2003
- GPS selective availability eliminated 2000
- **High resolution small displays ~2000**
- DC-DC converters 70->95% efficiency ~2000
- **Small IMUs ~1998**
- Consumer lithium batteries ~1997
- Power efficient processors (StrongARM) 1996
- **CMOS camera 1995->2007**

70 Years of Investment


A SCIENTIST OF THE FUTURE RECORDS EXPERIMENTS WITH A TINY CAMERA FITTED WITH UNIVERSAL-FOCUS LENS. THE SMALL SQUARE IN THE EYEGLASS AT THE LEFT SIGHTS THE OBJECT

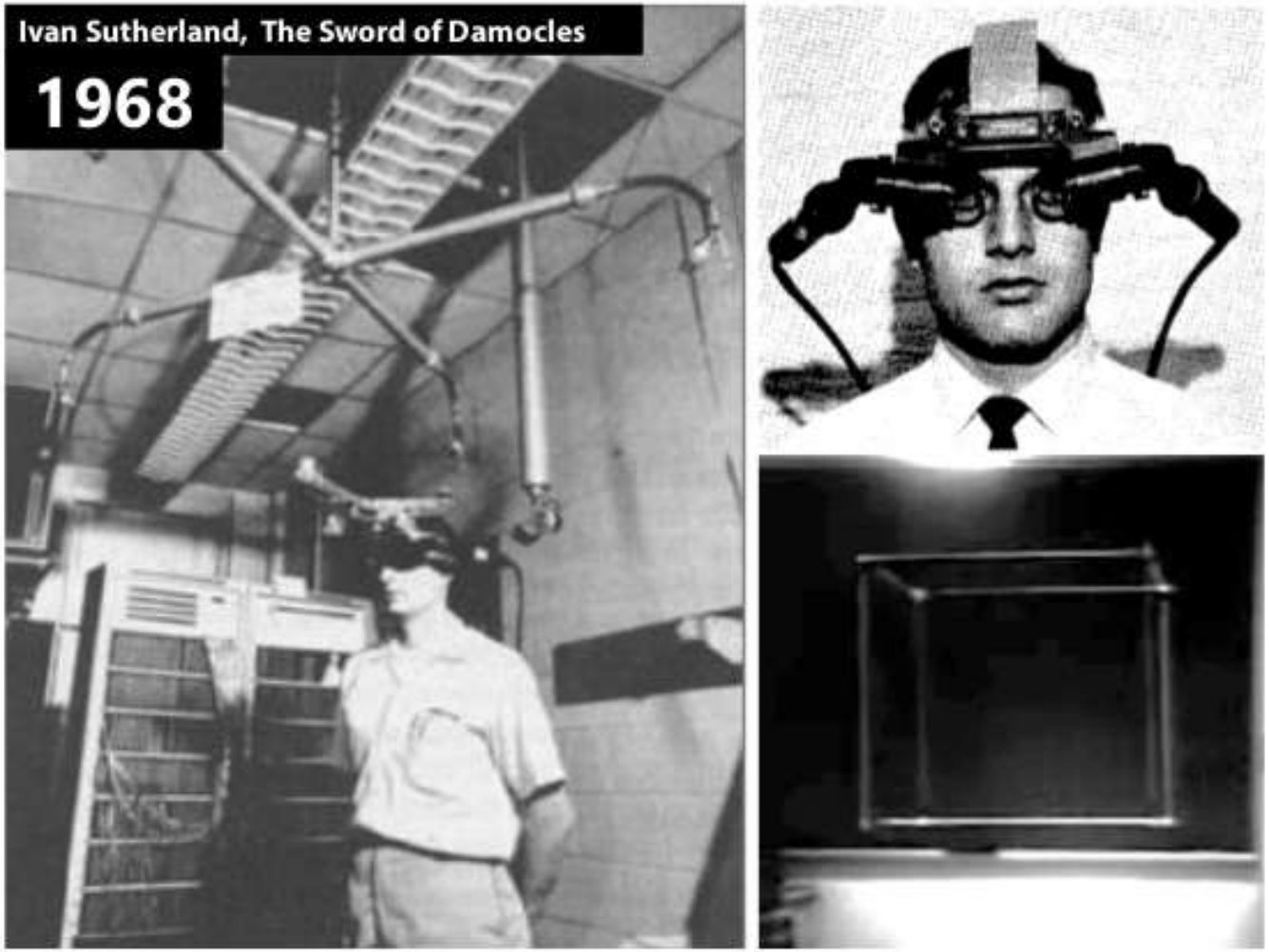
AS WE MAY THINK

A TOP U. S. SCIENTIST FORESEES A POSSIBLE FUTURE WORLD

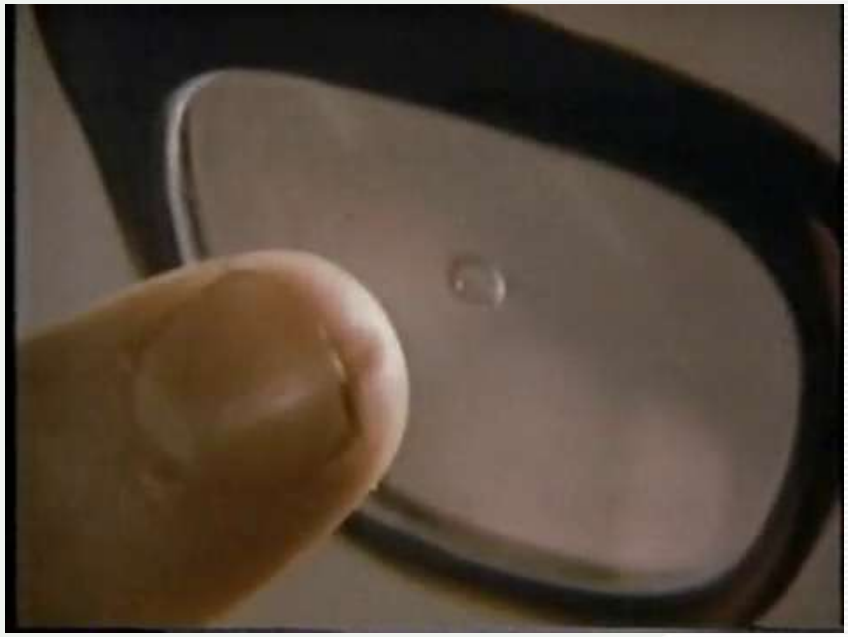
Vannevar Bush 1945

- National Science Advisor
- OSRD (science for warfare)
- Raytheon
- NASA precursor
- NSF precursor

Ivan Sutherland 1966



Microdisplays: Upton @ Bell (1967-1980s)



- Cued speech
- Helicopter HUDs for defense
- Scanning fiber bundles

Microdisplays: Upton @ Bell (1967-1980s)

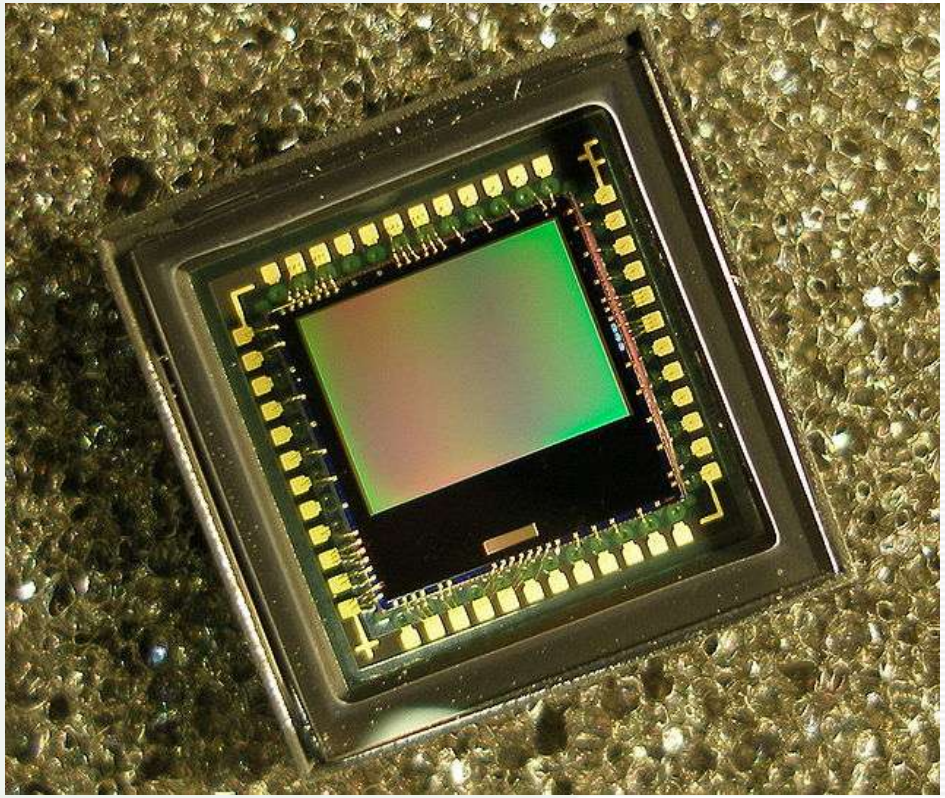
- Private Eye
- LEDs and scanning mirrors
- Military & beginnings of industrial interest
- Consumer VR 1995

Microdisplays (1990-now): Panels (Kopin, Displaytech, etc.)

Networking: 802.15

- Started as Ad Hoc Committee Meeting for Wearables Standards 1997
- Led by Dick Braley at Fedex
- Incorporated Bluetooth and Zigbee

Sensing: CMOS Camera (early 1990s)

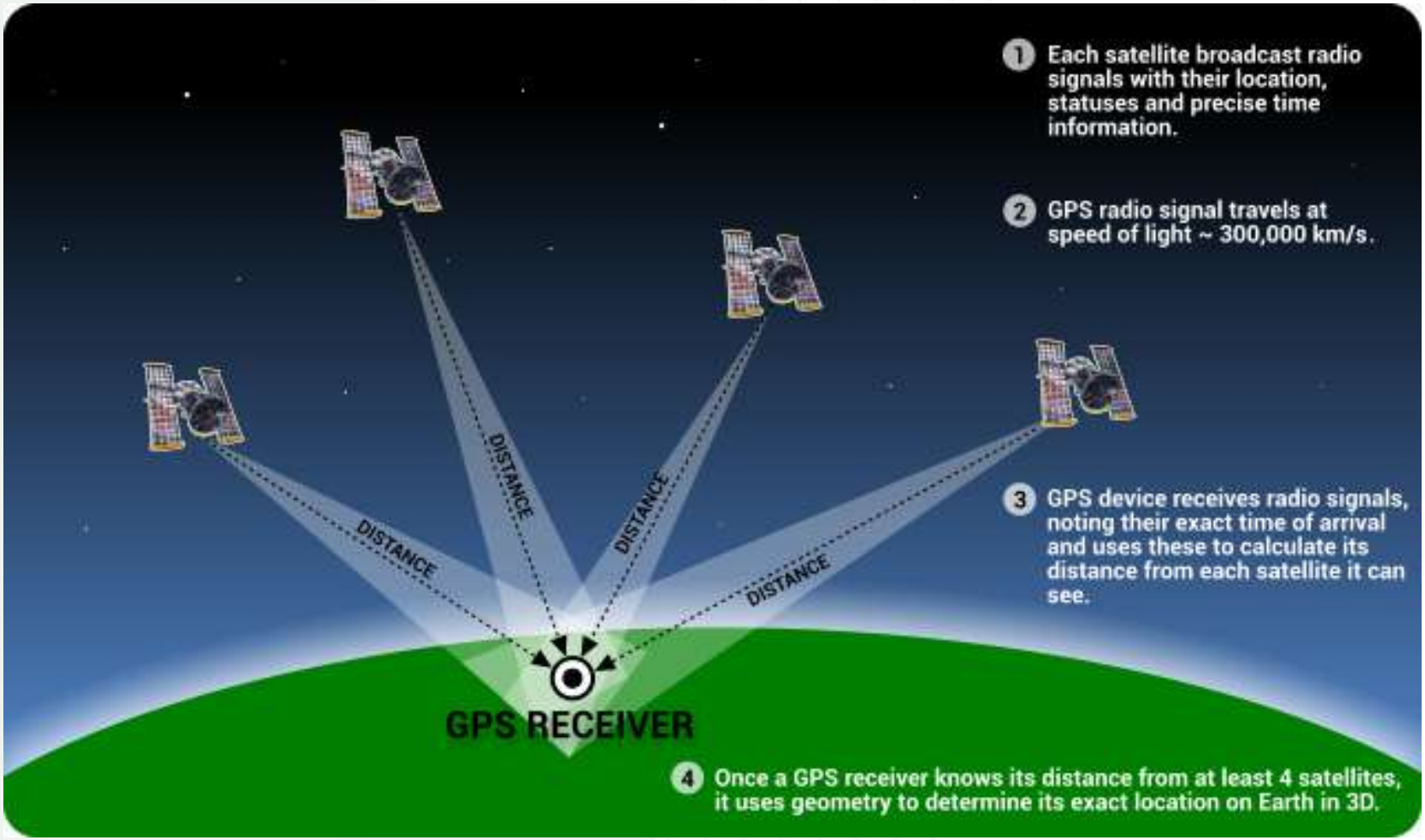


- Eric Fossum
- NASA JPL (1993-1995)
  → Photobit Corp.
  → webcam
  → cameraphones

Sensing: Inertial head trackers (late 1990s)

- Eric Foxlin, MIT (NASA, AFOSR, NRL)
- Intersense (SBIRs)
- 3x3mm high precision IMU chips today

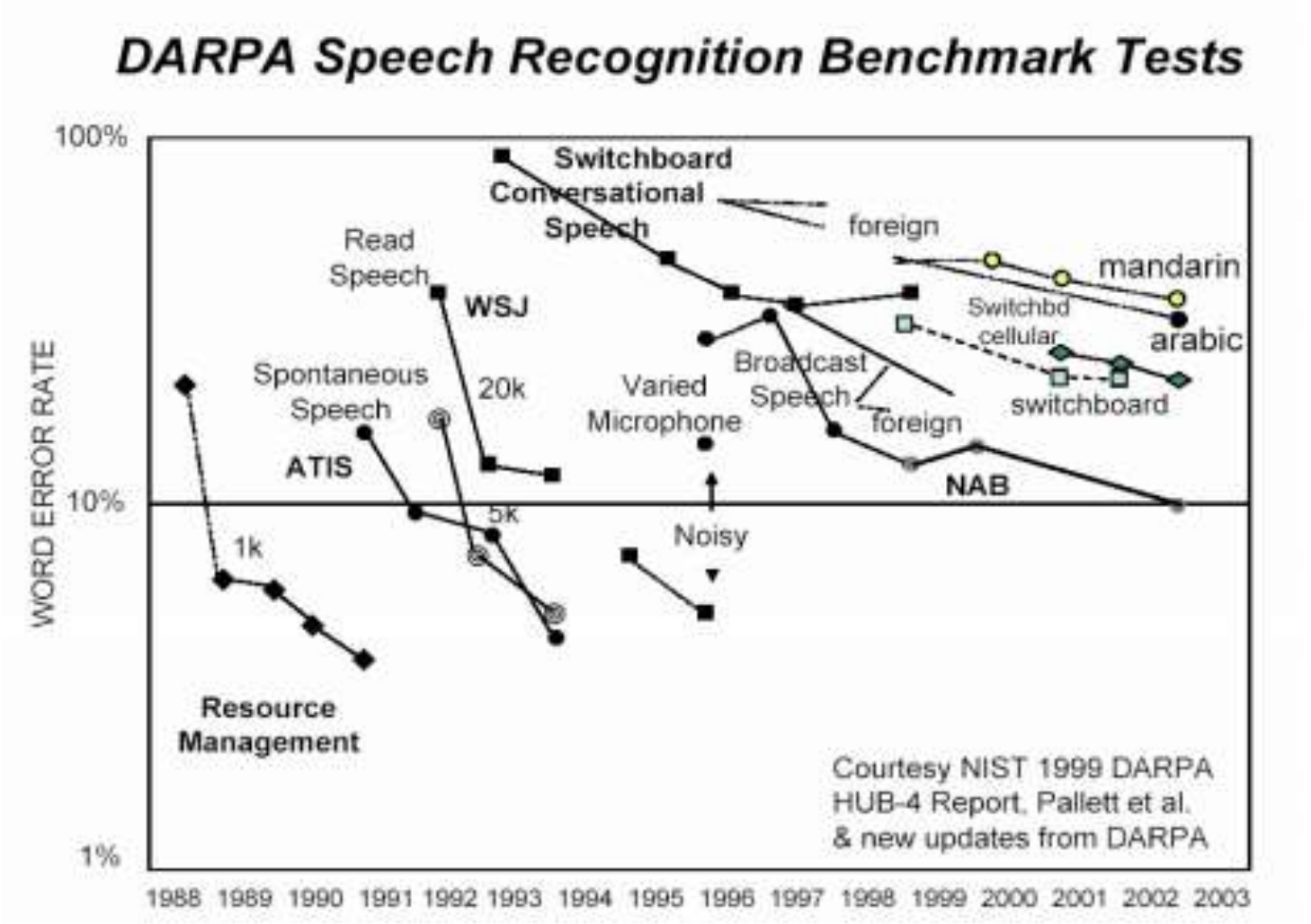
Sensing: GPS


1 Each satellite broadcast radio signals with their location, statuses and precise time information.
2 GPS radio signal travels at speed of light ~ 300,000 km/s.
3 GPS device receives radio signals, noting their exact time of arrival and uses these to calculate its distance from each satellite it can see.
DISTANCE
DISTANCE
DISTANCE
DISTANCE
GPS RECEIVER
4 Once a GPS receiver knows its distance from at least 4 satellites, it uses geometry to determine its exact location on Earth in 3D.

Sensing: Speech Recognition

- Bell Lab Audrey 1952; IBM Shoebox
- HMMs: Institute for Defense Analyses (60s)
- DARPA Speech Understanding Research 1971-1976: CMU Hearsay, BBN HWIM, …
- DARPA/NIST Tasks 80s-90s (ATIS, Switchboard, WSJ, Resource Management): CMU Sphinx, BBN BYBLOS, SRI DECIPHER

Sensing: Speech Recognition



Suddenly! Wearable Computing!

Symbiotic AI

Interweave a computer with something that is already intelligent (i.e., the user)

- Put cameras where my eyes are
- Put microphones where my ears are
- Put motion sensors at my hands
- If possible, look into brain for focus of attention and “intent”

Learn how to interact with the human world by observing a human interacting with the world

Bonus slides

Improving Learning (optional)

PHL & PHR (Morse Code on Glass, audio for piano on Glass, Braille, etc.

Douglas Engelbart 1962

By 'augmenting human intellect' we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems … we include the professional problems of diplomats, executives, social scientists, life scientists, physical scientists, attorneys, designers—whether the problem situation exists for twenty minutes or twenty years … way of life in an integrated domain where hunches, cut-and-try, intangibles, and the human "feel for a situation" usefully co-exist with powerful concepts, streamlined terminology and notation, sophisticated methods, and high-powered electronic aids.

Douglas Engelbart NLS/Augment

- the mouse
- 2-dimensional display editing
- in-file object addressing, linking
- hypermedia
- outline processing
- flexible view control
- multiple windows
- cross-file editing

- integrated hypermedia email
- remote procedure call protocols
- hypermedia publishing
- document version control
- shared-screen teleconferencing
- computer-aided meetings
- formatting directives
- context-sensitive help
- distributed client-server architecture
- uniform command syntax
- universal "user interface" front-end module
- protocols for virtual terminals

JCR Licklider (DARPA IPTO) 1960

"Man-computer symbiosis" is a subclass of man-machine systems. There are many man-machine systems. At present however, there are no man-computer symbioses. ... The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today.

Rod Brooks: Embodied Cognition

Pursuing Consumer Product: Possible → Practical in 25 years

Interface:
Consumer (Georgia Tech & MIT)

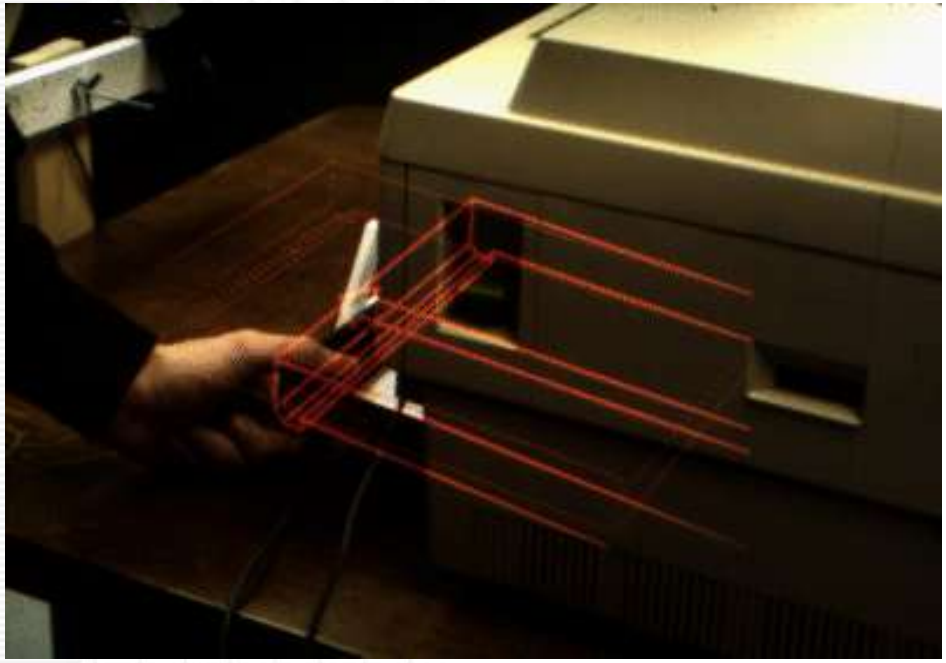
(US Air Force Lab. Grad. Fellow, Industrial Consortia, NSF)

Interface: Task Guidance (CMU)

Current practice	SAVINGS FACTOR	VuMan 3
	**Personnel** **2 : 1**	
Current practice	**SAVINGS FACTOR**	**VuMan 3 Field Trial**
	**Total inspection and data-entry time savings** **70 percent**	

(NSF ERC, NSF, DARPA)

Interface: Augmented Reality (Columbia)



(ONR, NSF)

Microdisplays: VR HMDs (early 1990s)

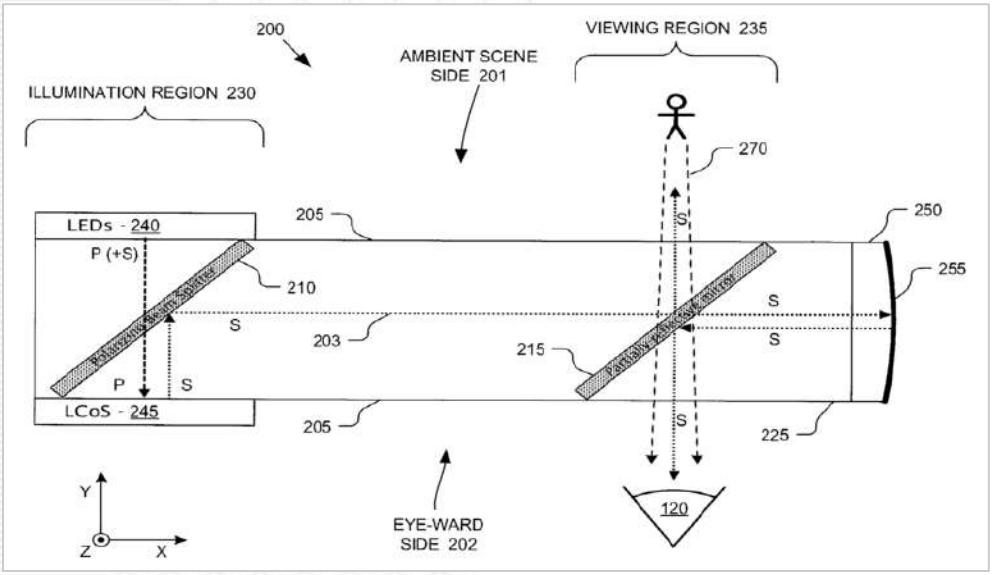
(NASA, DARPA)

Microdisplays:
Military, Industrial, Hobbyist (90s)

Microdisplays: Video Viewers (early 2000s)

Microdisplays: On-the-go Displays

(MicroOptical 1997)



(Google Glass 2013)

Bonus Slides

Other Topics

- Web search (Google NSF)
- Question answering (IBM Watson, govt academia, industry)
- Bone conduction audio
- Auto-awesome
- Batteries
- DC-DC


TOM FORD BLACK AND
ORANGE JERSEY DRESSES
WITH COMIC-BOOK BEADED
MOTIFS. TOM FORD
BEVERLY HILLS. CASADEI
ANKLE BOOTS. RIGHT,
GIUSEPPE ZANOTTI DESIGN
PLATINUM NECKLACE