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Voice in the Head: Prospects for Discrete Real Time Social Analytics

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Human Social Analytics (HUSO)
March, 2025

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Forty-five years experience in conducting sponsored research for a variety of military and commercial customers

Career highlights: 35 years as Research Scientist at the Georgia Tech Research Institute (GTRI), Atlanta, Georgia, USA
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Problem Solutions, LLC (Chief Human Systems Scientist)

Evolution of Technology

Power

- Earliest tools depended on human power
- Engineers improved ways to harness gravity, wind, and other natural sources
- Service animals allowed improved performance of some functions
- Engineers created and improved the tools of *human-machine-animal systems*

Information Processing

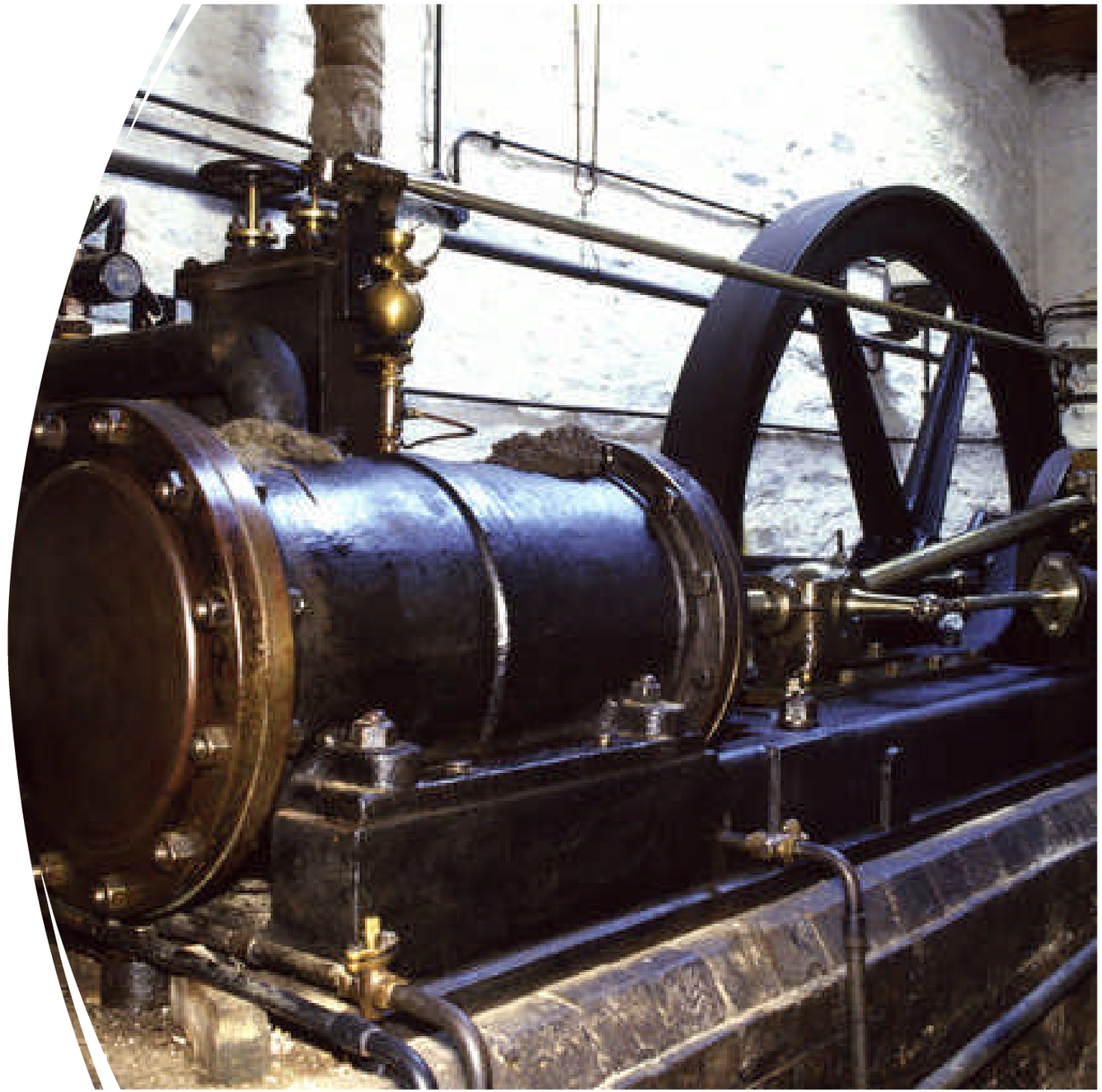
- Human intelligence performed all information processing in early systems
- Service animals provided some information processing capabilities, supervised by humans
- Improvements came from training and experience of humans and animals, and selective breeding of animals to improve certain traits.

Human Intelligence + Animal Power + (Relatively) Simple Machines

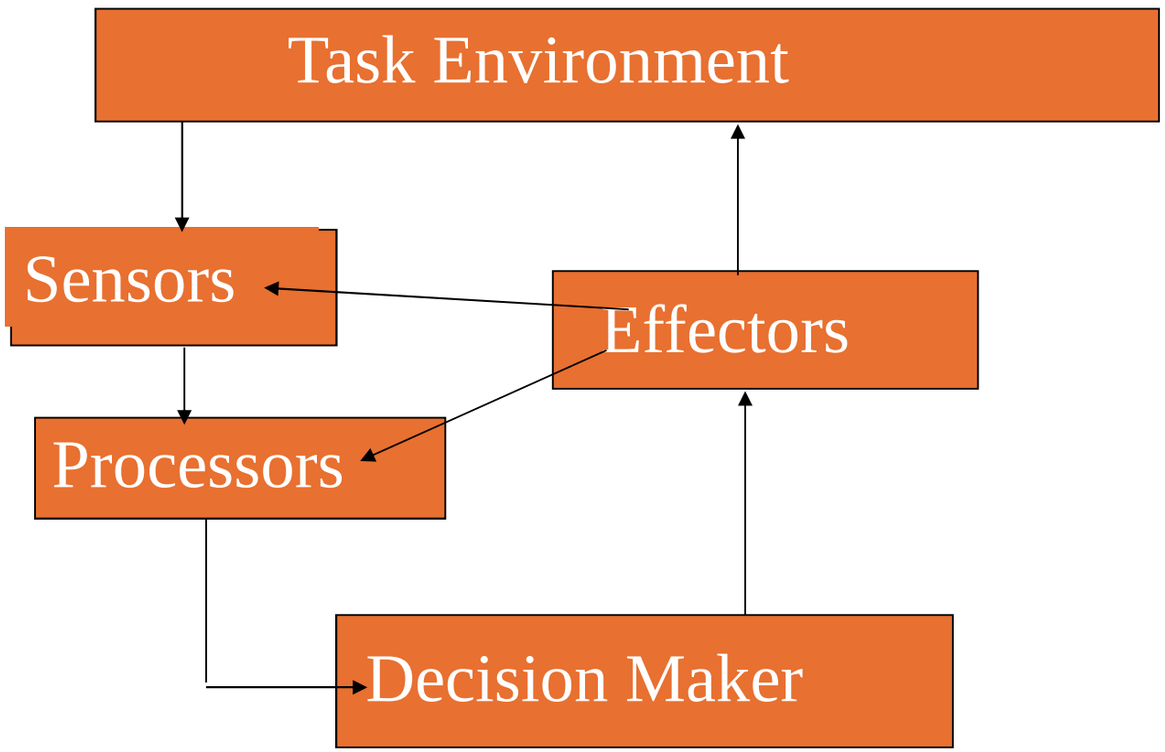
Human Intelligence +
Specialized Animal Skills
+ (More Complex)
Machines

The Age of Machines

- Shift to engineered sources of power
- Diminished reliance on animal power or animal intelligence
- Gradual development of capabilities machine-based information processing

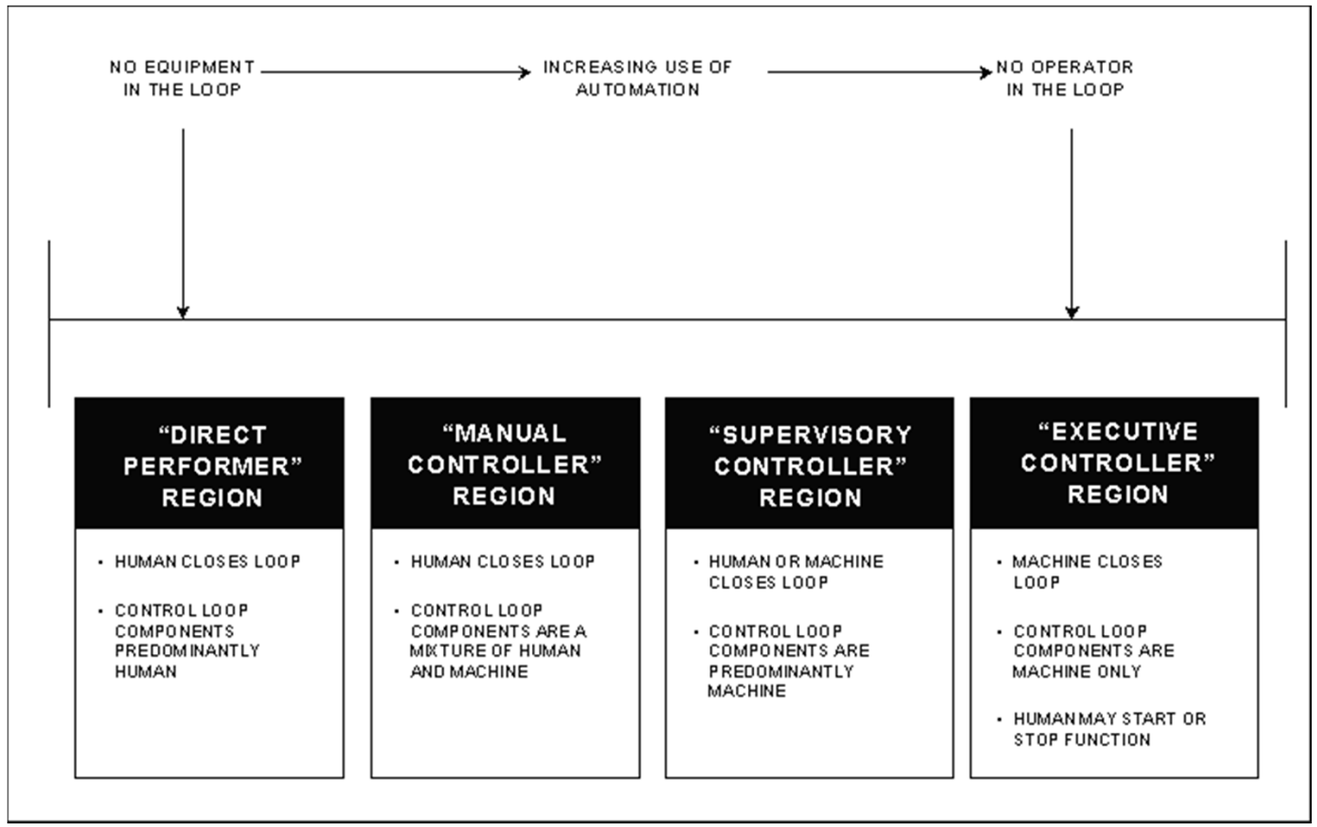


The Information Processing Loop



Human-Machine System

Continuum of Human Roles



Spiraling Complexity

- As machine capabilities mature, engineers put them together in new ways to create new functionality
  - Things that “just work” get used in new Direct Performer functions
  - Human uses a telephone to talk to someone else
- Combinations of things that rely on human decision making for coordinating their activity get used in new Manual Controller functions
- New machine-based decision making capabilities are implemented as Supervisory Controller functions
  - Until they get good enough for Executive Control

Trajectory

- Improves conditions for individuals, groups, and societies
  - Improved health and wellbeing
    - Nutrition, lower disease burden, improved security
  - Extended lifespan and life expectancy
    - Improved infant mortality rates
    - Increase in disability-adjusted life years (DALY)
  - Increased standard of living
    - Access to, and consumption of, goods and services
- Increase in leisure time
- Particular benefits for lower socio-economic status (SES) people

Challenge

- Create assistive AI/ML technology that can discretely deliver information that will:
  - Improve everyday life
  - Increase subjective well being
  - Compensate for functional limitations
- Use AI/ML and HUSO to support these functions:
  - Supporting education and life-long learning
  - Improving health and fitness
  - Aiding in job/task performance
  - Maintaining independent living across the lifespan
  - Facilitating treatment and management of acute and chronic conditions

Conversational Assistance

- Assisting, coaching, and mentoring generally involve verbal communications
  - Prompts
  - Explanation and elaboration
  - Interactive queries
- Private settings: normal conversational style
- Public settings: discrete dialog, generally imperceptible to others nearby

Strategic Goal: Voice in the Head (VITH)

- Leave the ear canal open, not occluded by headphones
  - Normal perception of ambient sounds and voices
  - Especially important for users who are blind
  - Also important in threatening environments
- Leverage bone conduction technology
- Mobile devices allow integration into everyday experiences
  - AR glasses / goggles & bone conduction (BC) headphones
    - Possibly combined into single device
  - Locally controlled by personal smartphone (etc.)
  - Augmented by other wearables (e.g., smartwatch)

Psychophysics – Research Agenda

- Equal loudness contours for BC transmission
  - Different mounting points have different properties
  - Best mounting points may not be compatible with integration into glasses
- Speech comprehension at near-threshold presentation levels
  - Could affect word choice as some phonemes are conducted more effectively (e.g., some unvoiced consonants have poor conduction)
- Need algorithms for adaptive presentation in dynamic ambient conditions
  - Detection vs. comprehension in nearby listeners

Application Examples

- Experiential Learning Maven in Real World Conditions
- Social and Cognitive Assistant for People with Functional Limitations
- Cognitive Load Manager in High Stress Situations

Experiential Learning: Language

Context: User is acquiring and developing command of a foreign language

- Learning includes interaction in virtual reality (VR) with gradual acquisition of vocabulary, grammar, diction, prosody, and idiom, guided by a language maven
- **VITH Support:** In real world conditions, the maven monitors ambient conversations and provides cues, prompts, and suggestions via discrete VITH channel
  - Primary goal is to promote learning and increased fluency in the new language

Note that this is different than simply having an AI-based translator

Experiential Learning: Place and Navigation

Context: User is learning about a new place (e.g., intended tourist destination)

- Learning includes exploration in VR, guided by a maven
- Acquiring knowledge about attractions, and navigation in the destination

- **VITH Support:** In real world conditions (at the destination), the maven provides prompts and other assistance via VITH channel
  - Assists in walking, driving, and public transportation
  - Provides reminders about significant cultural sites, etc.

Note this is different than a tour guide or turn-by-turn route guidance

Functional Limitations: Autism Spectrum

Context: A person with ASD struggles with reading social cues.

- **VITH Support:** AI provides real-time **conversation coaching**, such as:
  - Recognizing facial expressions and tone.
  - Suggesting appropriate responses or exit strategies.

- **Example:** *“John just crossed his arms and leaned back—he may be losing interest in the topic. Consider asking him a question about his interests.”*

Functional Limitations: Memory Loss

- **Context:** A person with mild cognitive impairment forgets details about people they meet.
- **VITH Support:** AI functions as an **augmented memory**, discreetly providing names, past interactions, and personal details.
- **Example:** *“This is Dr. Smith—you met at last month’s conference. He has two kids and enjoys sailing.”*

Functional Limitations: Visual Impairment

- **Context:** A blind individual moves through a complex environment.
- **VITH Support:** AI integrates **computer vision and environmental data** to provide real-time navigation.
- **Example:** *“You’re approaching an intersection. The pedestrian light is red—wait to cross.”*

Functional Limitations: Speech Impairment

- **Context:** A person with a degenerative condition struggles with speech fluency.
- **VITH Support:** AI **predicts and suggests words**, subtly prompting the user to maintain fluid conversation.
- **Example:** *“You might say: ‘I’d love to hear more about that.’”*

Cognitive Load Manager: Medical Emergency

- **Context:** A paramedic performs under pressure.
- **VITH Support:** AI provides **situational reminders, alerts, and decision support** while keeping cognitive overload low.
- **Example:** *“The patient’s O2 level just dropped—consider supplemental oxygen.”*

Cognitive Load Manager: Negotiations

- **Context:** A diplomat at a tense negotiation session.
- **VITH Support:** The AI analyzes speech patterns and body language to detect deception or shifts in tone.
- **Example:** The AI quietly alerts, *“The minister’s tone suggests reluctance. Try a softer approach.”*

Cognitive Load Manager: Tactical Support

- **Context:** A field operative requires critical information without looking at a screen.
- **VITH Support:** AI provides **silent, real-time mission updates, enemy positioning, or extraction routes**.
- **Example:** *“Thermal scan from UAV detects movement ahead. Approach with caution.”*

Ethical Considerations and Design Issues

- **Privacy & Trust**
  - Ensure **AI only activates when needed** to avoid unwanted intrusions.
  - User retains control over AI prompts.
- **Adaptive Learning**
  - AI **personalizes guidance** based on **user preferences, cognitive load, and social context**.
- **Latency & Edge Computing**
  - Real-time processing must be **fast and reliable**, possibly leveraging **edge AI** for offline scenarios.
- **Multimodal Integration**
  - VITH AI could **combine speech with haptic feedback** (e.g., subtle vibrations on wrist to indicate urgency).

Ongoing and Planned Research Program

- Psychophysical experiments with BC technologies
  - Dissertation and other graduate student research
  - Focus on perceptual effects

- First VITH Prototype
  - Military officer training program
    - Physical Fitness
    - Academic Course Requirements
    - Focus on content

Conclusion

- The trajectory of technology development led to great improvements in human conditions
- Potential improvements are identified from using AI/ML supplemented by HUSO
- Discrete delivery of conversational prompts through VITH channels
- Significant research challenges should be tackled

Questions?

- For more information, contact

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