

# The Intel Science and Technology Center for Embedded Computing

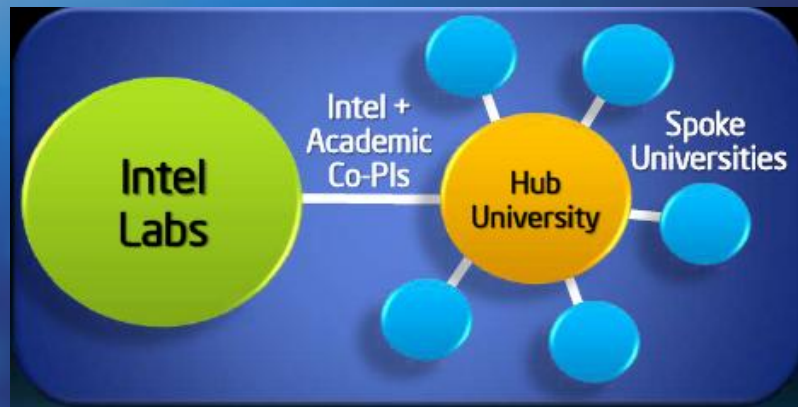
*Investing in New Levels of Academic Collaboration*

Jeff Parkhurst, Program Director ISTC-EC

Mei Chen, Intel Principal Investigator

Professor Priya Narasimhan, CMU Academic Principal Investigator

# The Intel Science and Technology (ISTC) Program



- ISTCs funded for 3+2 years and span multiple institutions
- Encourage collaboration among the best researchers in the field
- Four Intel funded researchers per center work on-campus
- Encourage collaboration between Intel and academia
- Public domain IP and open source software increase impact

# Introducing...

## The Intel Science and Technology Center for Embedded Computing



Carnegie  
Mellon  
University

Mei Chen

*Intel* Co-Principal Investigator

Research: Computer vision

At Intel since 2006

Carnegie Mellon alumnus

Previously at *HP Labs* and *Sarnoff Corporation*

Tech transfer to 5 HP products

Priya Narasimhan

*Carnegie Mellon* Co-Principal Investigator

Research: Embedded systems

At CMU since 2001

Intel Labs Pittsburgh director, 2010

Founder and CEO, *YinzCam*

Previously Founder and CTO of *Eternal Systems*



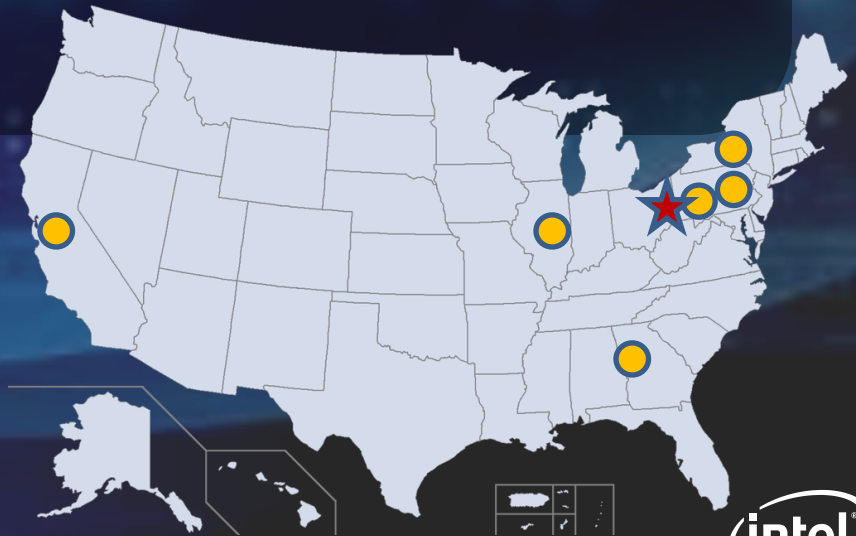
# The Intel Science and Technology Center for Embedded Computing (ISTC-EC)

- ISTC-EC Brings together thought leaders to drive research and transform experiences in the **Retail, Automotive** and **Home** of the future.
- Popularity of real-time intelligent and personalized technology is growing providing a corresponding rise in demand for specialized embedded computing systems to support a broad range of new applications — many yet to be envisioned.
- Three unique features designed to increase the probability of successful collaboration
  - Open collaborative research model
  - Multidisciplinary approach
  - “Hands-on” involvement of Intel

# Distributed Collaboration Center

Faculty + Graduate students + Intel

- Carnegie Mellon is the hub of the ISTC-EC, coordinating research among:
  - Cornell
  - Georgia Tech
  - Penn State
  - University of California , Berkeley
  - University of Illinois at Urbana Champaign
  - University of Pennsylvania



# Goals

Co-evolve algorithms and hardware/software architectures to deliver innovative embedded solutions, motivated by application domains

- Algorithms

- Analyze heterogeneous data, at scale
- Understand human behavior and intent
- Understand the environment within the context of human behavior
- Understand the interaction between human and the environment
- Enable interpretation, decision, predict future action

- Systems

- Enable algorithms in resource-constrained environments
- Enable seamless, large-scale computation in location/platform-agnostic way
- Enable crowd-sourced networked operation
- Enable real-time, high-performance, robust hardware and software
- Enable strategic interactions with cloud-computing environments

# Application-Inspired Research

## APPLICATION DOMAINS



Retail



Automotive



Home

## RESEARCH THEMES

Collaborative Perception

Real-time Knowledge Discovery

Robotics

Embedded Systems

	Retail	Automotive	Home
Collaborative Perception			
Real-time Knowledge Discovery			
Robotics			
Embedded Systems			

# THEME: Collaborative Perception

- Over-arching goals
  - Perceive accurately and react timely by synthesizing multi-modal data, leveraging learned prior, incorporating contextual information
  - Attention/intent analysis, behavior understanding
  - Interaction between human and environment
- Some projects of interest
  - Behavior and environment understanding using first-person sensing
  - Third-person human understanding
  - First-object dynamic scene understanding within the automotive context
  - Real-time 3D reconstruction



# THEME: Real-time Knowledge Discovery

- Over-arching goals
  - Extract information from data from both online and the physical world in a timely, scalable and reliable manner
  - Pattern discovery in con-current event streams
  - Anomaly mining
  - Learning from heterogeneous, high-dimensional data
- Some projects of interest
  - Never-ending web-scale massively parallel machine learning
  - Dimensionality reduction and distance metric learning to enable embedded solutions
  - Imitation learning

# THEME: Robotics

- Over-arching goals
  - Support multi-sensory exploration
  - Manipulation in human environment
  - Indoor navigation, obstacle detection/avoidance, planning
- Some projects of interest
  - Manipulation of deformable objects such as clothing
  - Reinforcement/imitation learning for manipulation
  - Automated planogram robots for retail environments
  - Embedded solution for high-precision localization

# THEME: Embedded Systems

- Over-arching goals
  - Enable perception and knowledge discovery in a timely manner
  - Respect power/memory/computational constraints
  - Acquire data about human and environment (location, proximity, etc.)
- Some projects of interest
  - Embedded-to-cloud gateways for sensor networks
  - Embedded hypervisors for location-agnostic, device-independent experience
  - Multi-sensor embedded platforms for automotive telematics
  - SoCs and accelerators for machine learning and perception

# Application Domains



## RETAIL

- Transformative experience for the shopper
- Transformative experience for the in/cross-store retail operations



## AUTOMOTIVE

- Transformative experience for the driver
- Transformative experience for the occupants



## HOME

- Transformative experience for the residents
- Transformative experience for in/cross-home management

# Retail 2020 Vision

- Transformative experience for the **shopper**
  - Locate product in real-time (in this store or other branches)
  - Store recognizes shopper's preference and makes relevant suggestions
    - Allergies, nutrition, clothing preferences
  - Enable the shopper to experience products
    - Digital unboxing, virtual dressing-rooms
  - Socialize the shopping experience
    - Real-time sharing to get/give feedback/recommendations
- Transformative experience for **in/cross-store retail operations**
  - Real-time inventory and planogram integrity
  - Immersive and effective training for staff, reduce injuries
  - Free staff of automat-able tasks to provide more available and attentive customer service
  - Reduce misplacement and mislabeling of products



# Automotive 2020 Vision

- Transformative experience for the driver
  - Assist under adverse conditions (rain, snow, crowds)
  - Enhance trip efficiency/productivity
    - Customized recommendations/planning/deals for retail, dining, parking
  - Real-time cost consciousness
    - Telematics to enhance fuel efficiency
  - Real-time automated consultation of other drivers' experiences
    - Automated analysis of crowd-sourced sensory data of road and traffic
  - Portable driving experience
    - Capture preferences to "port" them to other vehicles for personalization
- Transformative experience for the occupants
  - Vehicle recognizes its occupants for customization
    - In vehicle entertainment
    - Routing, services (retail, dining, entertainment) recommendation



# Home 2020 Vision

- Transformative experience for the residents
  - Recognizing the residents to personalize/customize
    - Temperature, entertainment, work mode, family mode
  - Home automation
    - Do programmed tasks well, e.g. unload dish washer, fold laundry
    - Learn and improve on skilled tasks, e.g. cooking, ironing
  - Support for preemptive maintenance
    - Detect wear and tear, preemptive scheduling of maintenance
  - Simulated home occupancy to enhance security
- Transformative experience for in/cross-home management



# Long-Term Impact

- Advocate and foster algorithm-system co-design
  - Co-evolve
  - Co-adapt
- Transform algorithms research
  - Innovate while understanding challenges of *real world scenarios*
  - Optimize while negotiating *resource constraints* of embedded platforms
- Transform systems research
  - Innovate to influence and support algorithms of the *future*
  - Understand an algorithm beyond its being just a *workload*
- Shift cultural mind-set
  - Algorithms and systems do not function (nor are developed) in isolation
  - Success of ISTC depends on inter-disciplinary collaboration



Thank you