Building Interactive Systems
Learning & Prediction

Professor Bilge Mutlu | Spring 2023

What we will cover today

→ Interactive systems that learn

→ Reading group discussion

→ HACK 3 heads up

→ INTEGRATE Milestone 1 preview

Definitions[1] [2]

Learning: A learning algorithm is a software system that improves its performance in some task domain based on partial experience with that domain.

Adaptive Systems: An adaptive user interface is an interactive software system that improves its ability to interact with a user based on partial experience with that user.

Intelligent User Interfaces: Intelligent user interfaces (IUI) are driven by the goal of improvement in human–computer interaction (HCI), mainly improving user interfaces' user experience (UX) or usability with the help of artificial intelligence.

[1] Langley (2005). Machine learning for adaptive user interfaces. *In Proceedings KI-97*.

[2] Brdnik et al. (2022). Intelligent user interfaces and their evaluation: A systematic mapping study. *Sensors*.

Scope & Assumptions

→ For this lecture, we will adopt the IUI term for systems that learn, predict, and adapt.

→ Looking at learning and AI from the perspective of interactive systems.

→ Very large, sparse area — we will take an empirical approach to mapping it.

Basic Learning Terminology

→ **Timeframe:** *Learned* and/or *learning* systems[1]

→ **Approaches:** *Supervised*, *unsupervised*, *semi-supervised*, *reinforcement* learning[3]

→ **Model tasks:** Classification, clustering, regression/estimation

→ **Priors:** *Model-based* vs. *model-free* learning (e.g., RL) or decision-making[4]

→ **Data sources:** Sparse, multimodal, high-cost

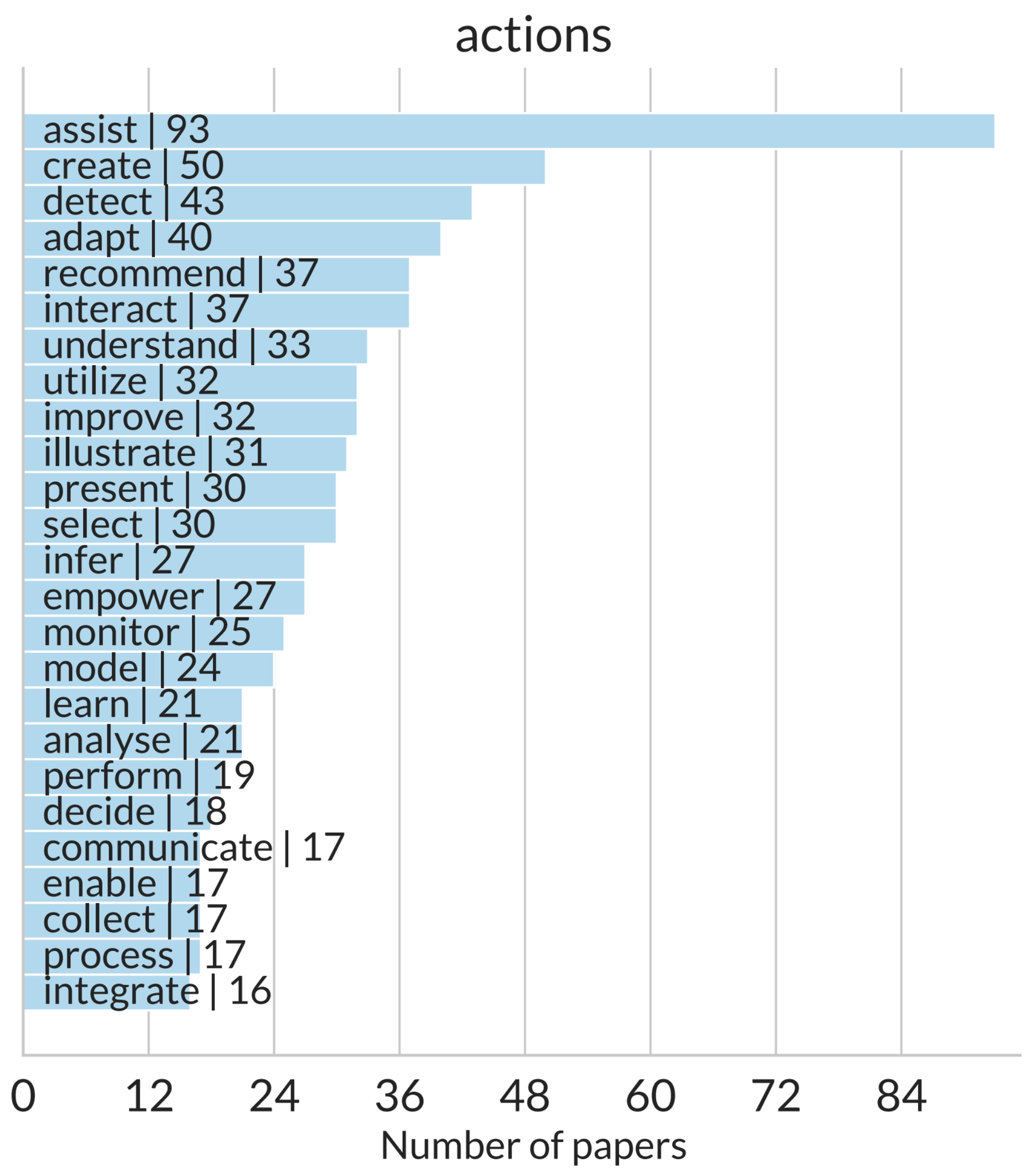
[1] Langley (2005). Machine learning for adaptive user interfaces. *In Proceedings KI-97.*

[3] SuperVize Me

[4] Lockwood et al. (2020). Model-free decision making is prioritized when learning to avoid harming others. PNAS.

What Do IUIs Do?

Meta-analysis of 25 years of IUI research[5]



[5] Völkel et al. (2020). What is" intelligent" in intelligent user interfaces? a meta-analysis of 25 years of IUI. In *IUI 2020*.

We will focus on the top six (but only cover those marked with "↞" today):

→ **Assist** — aid users in tasks (e.g., increasing task efficiency) ↞

→ **Create** — generate content (e.g., generating summaries)

→ **Detect** — capturing specific information (e.g., detecting emotions) ↞

→ **Adapt** — matching user characteristics (e.g., generating assistive interfaces)

→ **Recommend** — filtering information for users (e.g., book recommendations) ↞

→ **Interact** — enabling interaction with the user (e.g., natural language) ↞

For each category, we will discuss:

→ Context/task, learning approach, learning input, learning timeframe

Interactive Systems that Assist

Also called **generative interfaces**, which focus on the generation of some useful knowledge structure.[1]

Systems that augment human capabilities to perform tasks that might be took complex, too tedious, and/or generally undesirable.

[1] Langley (2005). Machine learning for adaptive user interfaces. *In Proceedings KI-97.*

Example Assistive System

Excel Flash Fill[6]

Task: Data cleanup

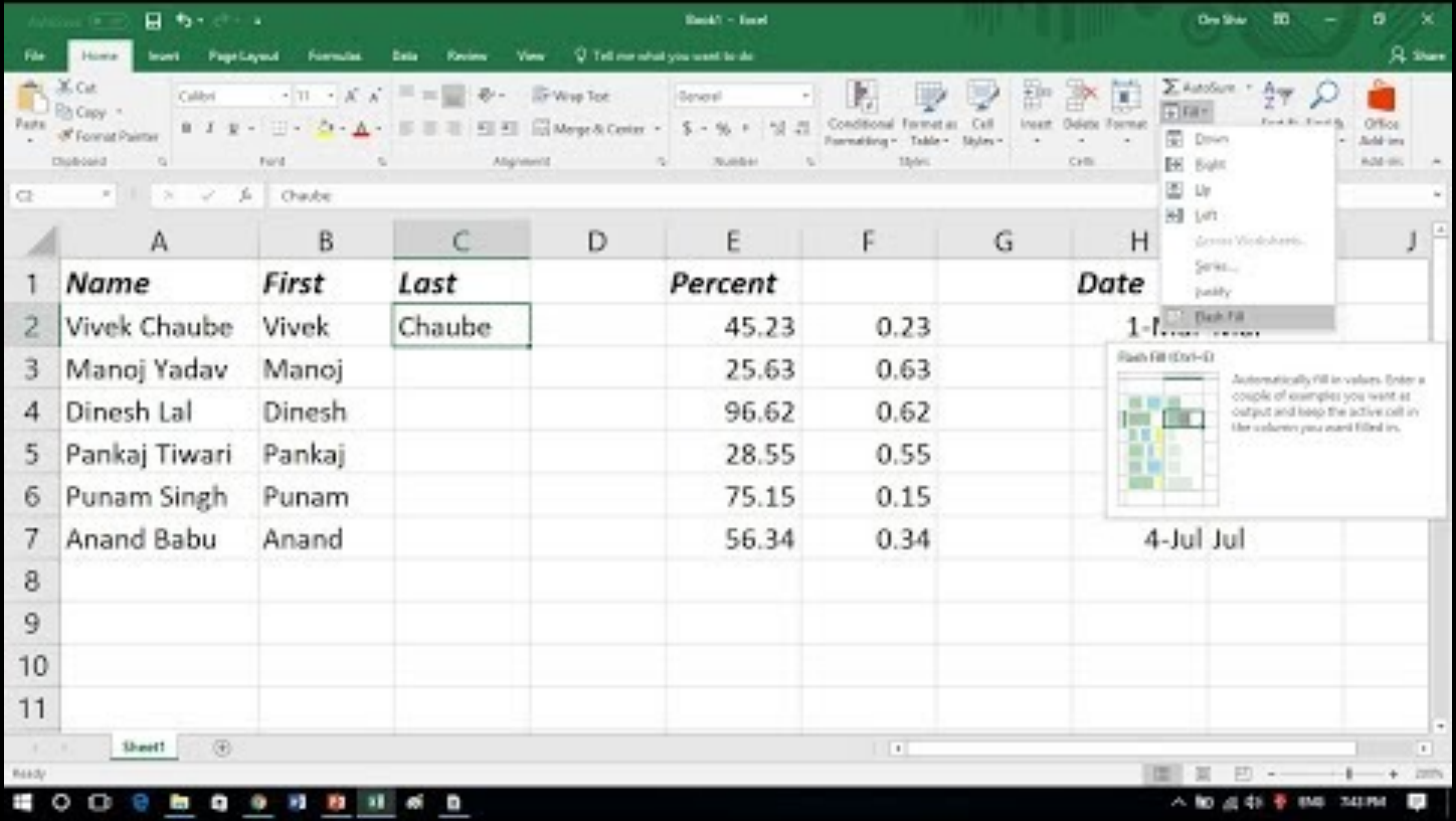
Learning approach: Interactive ML; Learning from demonstration

Learning input: User examples

Learning timeframe: Interactive, during task

	A	B	C
1	Name and ID	First name and last name	ID #
2	Thomas, Rhonda 82132	Rhonda Thomas	
3	Emmett, Keara 34231	Keara Emmett	
4	Vogel, James 32493	James Vogel	
5	Jelen, Bill 23911	Bill Jelen	
6	Miller, Sylvia 78356	Sylvia Miller	
7	Lambert, Bobby 25900	Bobby Lambert	
8	Sweet, Julie 65477	Julie Sweet	
9	Williams, Don 43920	Don Williams	
10	Spake, Deborah 33488	Deborah Spake	

[6] Image



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Pankaj Tiwari
Pankaj
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7

[7] YouTube

Detour: Learning Approach

- → Learning from Demonstration; Imitation Learning; Apprenticeship Learning; Interactive Machine Learning; One-shot Learning
- → **Low-level learning:** trajectory-based learning, supervised, reinforcement learning, policy search
- → **High-level learning:** inverse reinforcement learning, graph learning, skill learning
- → **Active learning:** policy learning, interactive learning, dialogue-based methods

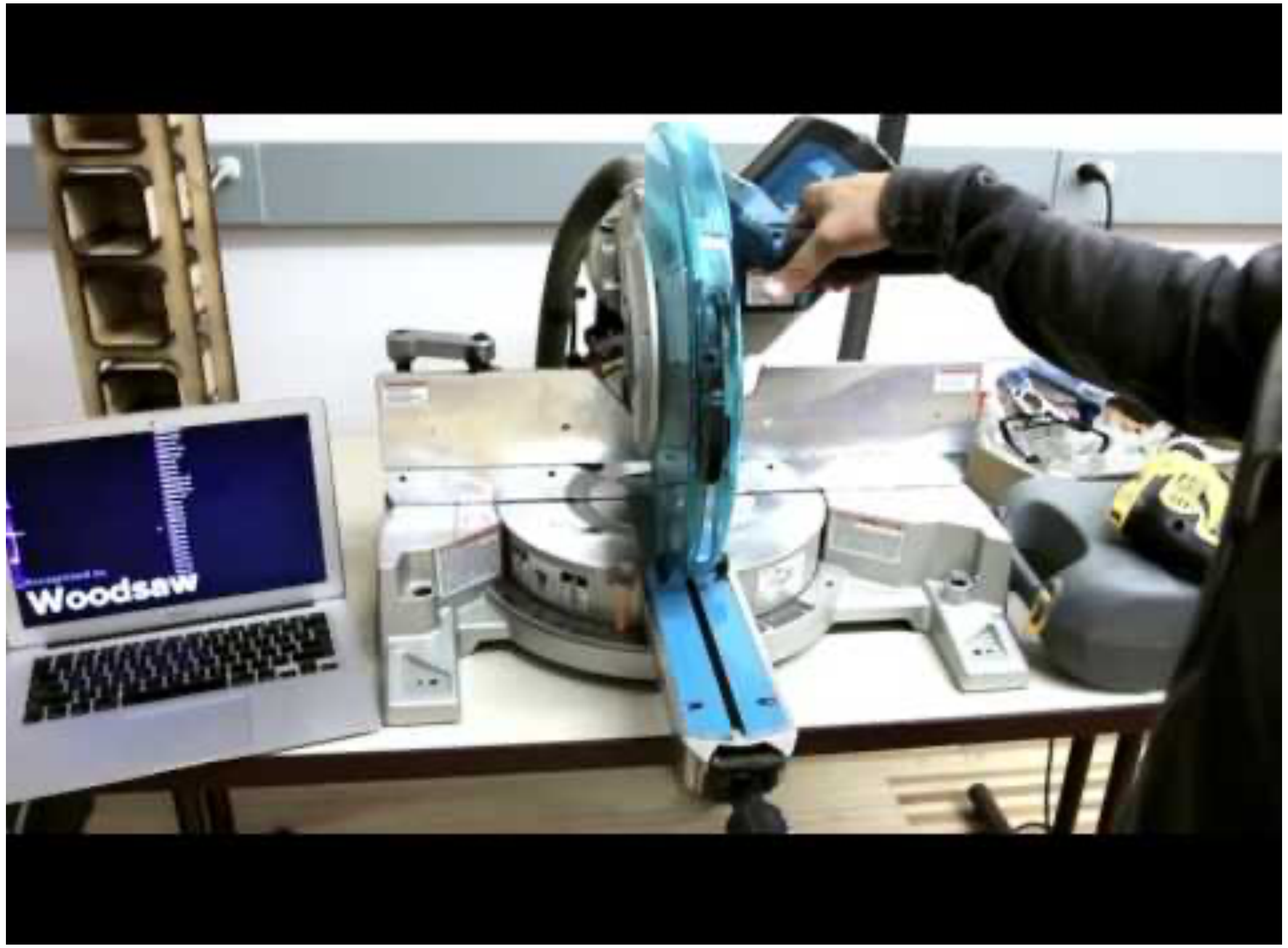
Interactive Systems that Detect

→ Systems that can detect users, their presence and activities, and distinguish among users and activities using "learned" models from prior data on the users and their activities.

Example **Detecting** System

Synthetic sensors[8] [9] [10]

Task: Detecting and differentiating between user activities



[8] Laput et al. (2017). Synthetic Sensors: Towards General-Purpose Sensing. In *CHI 2017*.

[9] Images

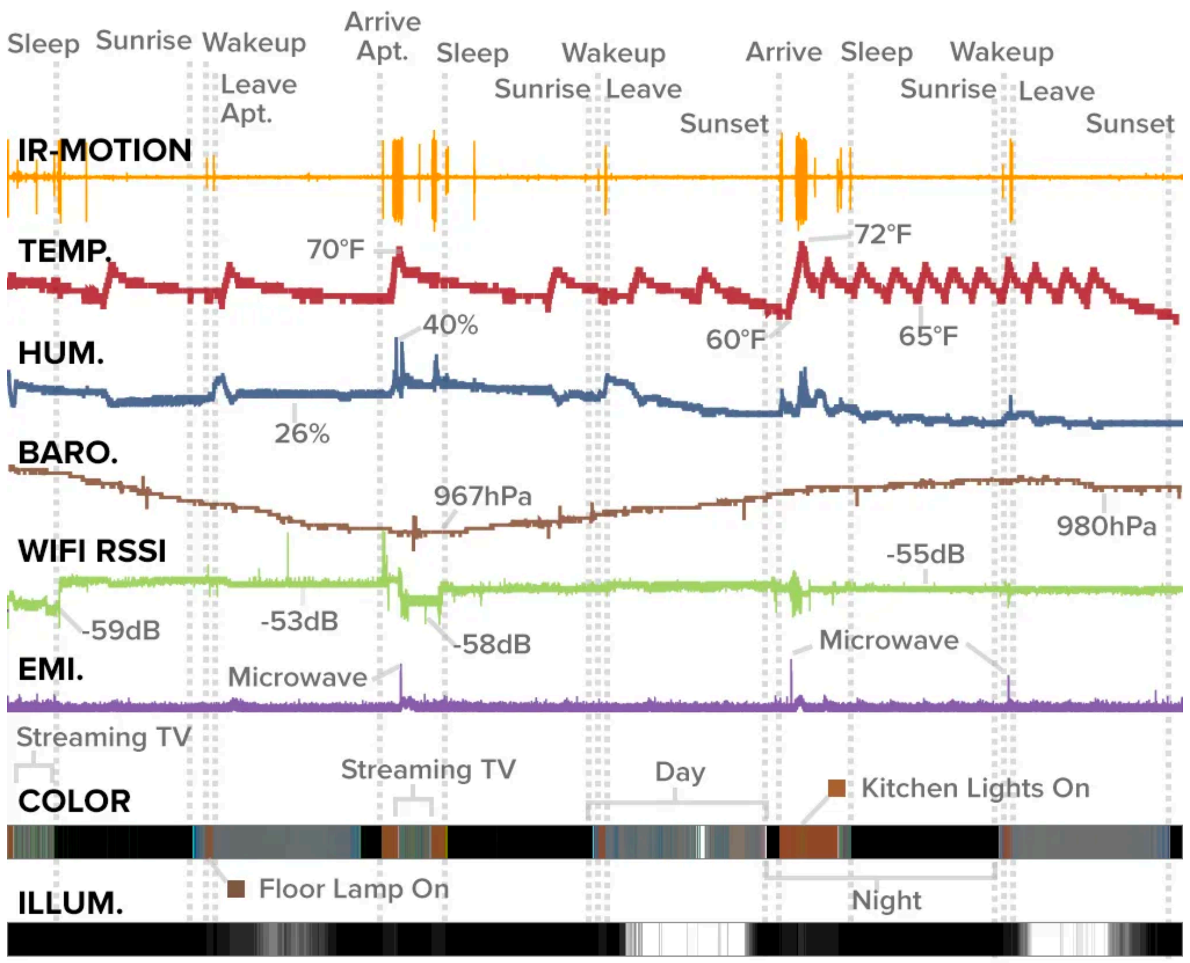
[10] YouTube

Synthetic sensors[8] [9] [10]

Learning approach: Batch learning using support vector machines (SVM)

Learning input: Sensor suite data (e.g,. motion, temperature, humidity, barometric pressure, WiFi received signal strength indicator (RSSI), electromagnetic interference, color, illumination)

Learning timeframe: Offline, users interact with a "learned" system



[8] Laput et al. (2017). Synthetic Sensors: Towards General-Purpose Sensing. In *CHI 2017*.

[9] Images

[10] YouTube

Interactive Systems that Recommend

→ Also called **informative interfaces**, which attempt to select or filter information for the user, presenting only those items he will find interesting or useful.[1]

[1] Langley (2005). Machine learning for adaptive user interfaces. *In Proceedings KI-97.*

Example Recommender System

Amazon Book Recommendation[11]

Task: Filtering through 33M books.

[11] Images: Top, Bottom

Amazon Book Recommendation[12]

Task: Filtering through 33M books.

Learning approach: Collaborative-filtering — e.g., user-based KNNs, graph-based association rules, matrix factorization (stochastic gradient descent, alternating least squares), deep NN[6]

Learning input: Set of users, set of items, recommendations

Learning timeframe: Offline, constantly updated, users interact with a "learned" system

[12] Machine Learning for Recommender systems

[6] Image

Interactive Systems that Interact

→ Systems that use AI methods to enable more effective or novel ways of interacting with users, e.g., through a better understanding of user activities, input, intent.

Example Interactive System

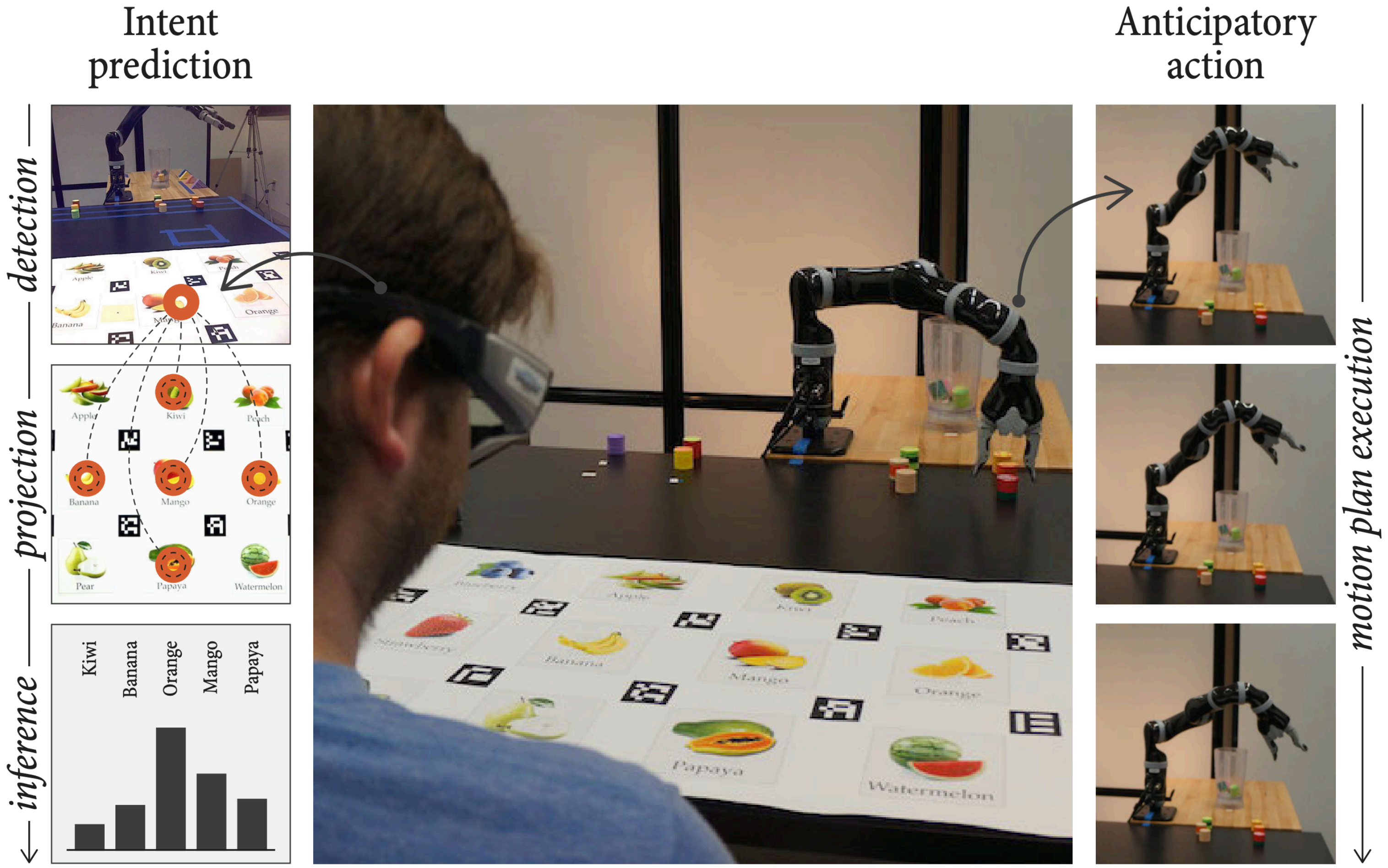
Anticipatory robot control[13]

Task: Predicting user intent

Learning approach: Batch learning, SVM

Learning input: Features of the user's gaze

Learning timeframe: A *learned* system



[13] Huang & Mutlu (2016). Anticipatory robot control for efficient human-robot collaboration. In *HRI 2016*.

Reading Groups

1. **Huang et al.:** Surprising that people can respond negatively to predictive systems.
2. **Horvitz et al.:** Success depends on task complexity.
3. **Yang et al.:** Transparency is difficult. Different problems require different amounts of data.
4. Meta learning to determine suitability for the use of learning-based system.
5. Clean design vs. intelligibility. How much to expose the learning to the user?
6. Is there a way to bring the tradeoff into marketing? Medical systems expose the confidence of the model.
7. Communicating confidence can help build user trust.

HACK 3 Heads Up

- → HACK 3 will be released on Wednesday
- → HACK 3 → HACK3+ (an *intelligent* version)
- → Same teams, same resources
- → Due in 2.5 weeks

INTEGRATE **Milestone 1** Preview

→ Four steps:

1. Literature survey → map of the state of the art + opportunities
2. Brainstorming → ideas capitalizing on the opportunities
3. Critique → narrowing down to *good* ideas
4. Idea refinement & articulation → communicating top-3 ideas

→ Due Friday

→ **Wednesday**: present where you are (5-10 minute presentation)