IN4MATX 133: User Interface Software

Lecture:
Alternative interaction

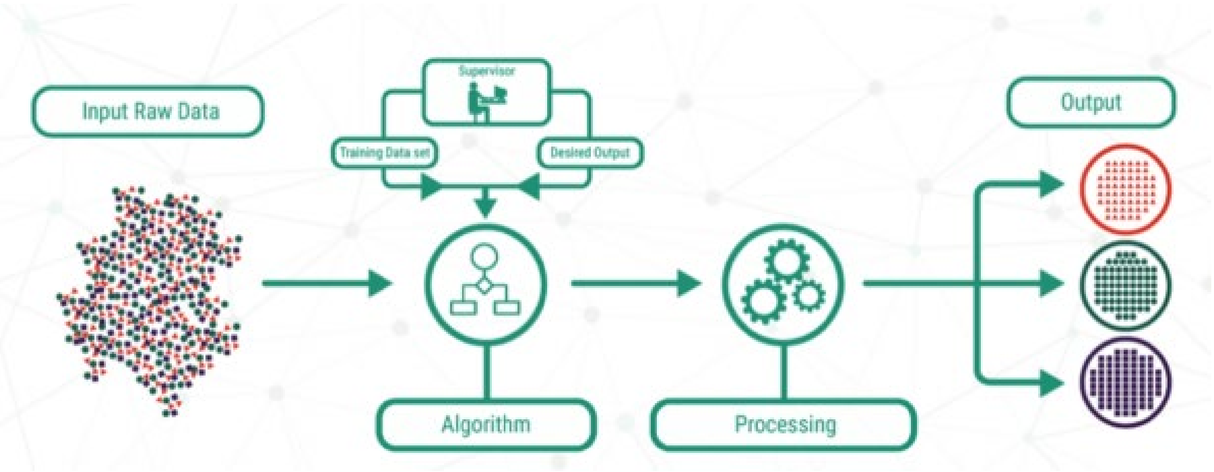
Today’s goals

By the end of today, you should be able to…

- Describe how machine learning works
- Describe how HandTrack.js and other alternative interactions make use machine learning
- Understand multimodal UI’s and how they can lead to a better user experience

Machine Learning

- The application of an [algorithm] on a [set of data] to make [predictions for computational actions].
- Algorithms
  - Supervised, unsupervised, and reinforcement learning algorithms
- Set of data
  - Sample data, or training data, is assembled into a model.
  - Model is input to algorithm
- Predictions for computational actions
  - Based on input model, algorithm predicts what the next action should be
  - E.g., avoid person, recognize object



https://www.ironhack.com/en/data-analytics/what-is-machine-learning

Machine Learning - Algorithms

- Supervised
  - Algorithms that learn from models with desired input and output
  - Ex. A data set of animals.
- Unsupervised
  - Algorithms that learn from models with desire input only
  - Output is predicted
  - Ex. Other movies you might like to watch
- Reinforcement
  - Algorithms that learn do not assume knowledge from a model, but rather predict output based on dynamic input.
  - Ex. Game A.I., self-driving vehicles

Machine Learning - Models

- Models are built from existing data
  - Dataset for model must be large (larger the better)
  - Data must be annotated (e.g., giraffe labeled as giraffe)
- Many datasets are kept private (costly to produce), but there are plenty also available for free
  - UCI provides many! (https://archive.ics.uci.edu/ml/datasets.php)

https://en.wikipedia.org/wiki/List_of_datasets_for_machine-learning_research

Machine Learning - Tools

- Many exist, but TensorFlow has become the primary entry point
- A platform for building and deploying machine learning
  - Can build new models
  - Apply existing models
  - Apply existing algorithms
  - Support for numerous languages, but Python is most used
- TensorFlow.js adds ML capability to the browser

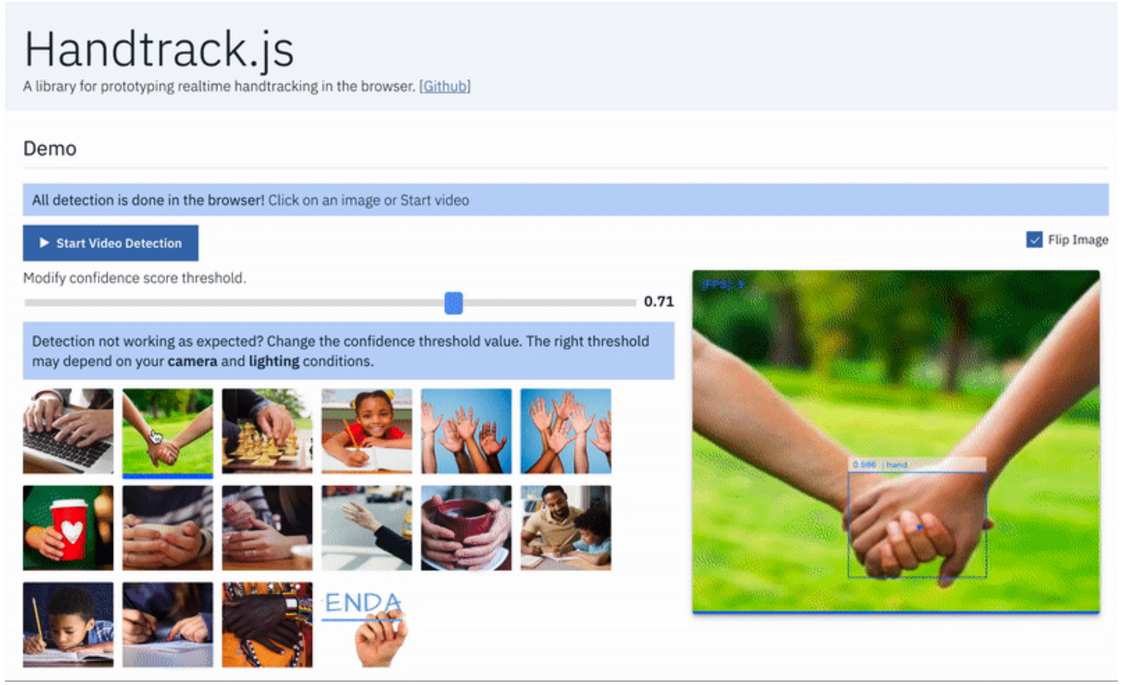
HandTrack.js

- Handtrack.js
  - Built on TensorFlow.js
  - Our version uses a model derived from the EgoHands dataset
    - Contains 15,000 examples of hands
    - Assembled from videos captured with Google Glass

http://vision.soic.indiana.edu/projects/egohands/

HandTrack.js

- Model is built with TensorFlow Object Detection API
- Trained model is then converted to a TensorFlow.js webmodel using TensorFlow.js tooling
- The handtrack.js code then loads the webmodel to make predictions based on inputs collected (static image or video)



https://towardsdatascience.com/handtrackjs-677c29c1d585

HandTrack.js

- Basic functionality of the library
  - Handtrack.js is a library that provides core functions and helper functions to process images
  - Load(params): accepts a params object and performs the initialization of the library. Returns a model object, required to make a prediction
  - Model object provides a “detect” function that will take an image as input and predict hand pose against the pre-built model

https://towardsdatascience.com/handtrackjs-677c29c1d585

HandTrack.js

- Basic functionality of the library
  - Params:
    - imageScaleFactor – Set to reduce the size of your image, thus improving prediction time (possibly reducing accuracy). Default is 1:1.
    - maxNumBoxes – The number of boxes to detect. If you only need one 1 hand, then set it to 2 (1 for face)
    - iouThreshold – “intersection of union,” how sensitive do you want your overlapping objects to be?
    - scoreThreshold – The higher the score, the lower the amount of detections you will get. Find a balance!

```
private modelParams = {
   flipHorizontal: true,
   imageScaleFactor: 0.7,
   maxNumBoxes: 20,
   iouThreshold: 0.5,
   scoreThreshold: 0.6,
 };
```

https://towardsdatascience.com/handtrackjs-677c29c1d585

HandTrack.js

- Basic functionality of the library
  - Prediction results:
    - Bounding box (bbox): The position and size of the detected object
    - Class: The predicted object (e.g., hand, face)
    - Label: The predicted gesture (e.g., open, closed, point, pinch)
    - Score: The confidence of the prediction. Higher score == greater likelihood of accurate prediction.

```
[{
  bbox: [x, y, width, height],
  class: "hand",
  label: “open",
  score: 0.8380282521247864
}, {
  bbox: [x, y, width, height],
  class: "hand",
  label: “closed",
  score: 0.74644153267145157
}]
```

https://towardsdatascience.com/handtrackjs-677c29c1d585

Machine Learning in UI

- How does all this apply to our work with user interfaces?
  - The ability to predict opens new directions for UI’s
    - Gestures (hand and full body)
    - On-body interaction
    - Eye-gaze
    - Speech

Machine Learning in UI

- On-body Interaction
  - Armband detects muscle deflection
  - Deflections can be modeled to predict on body location
  - Projected overlay coordinates with predictions to identify input and perform output

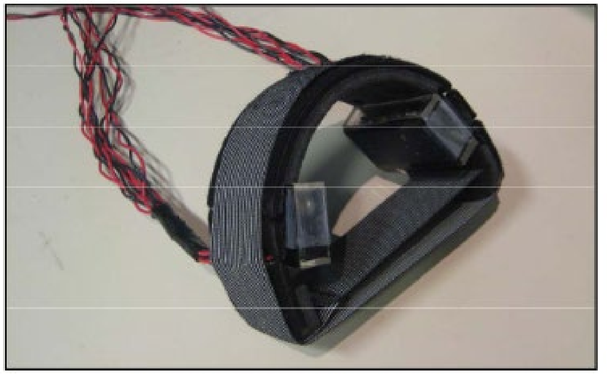
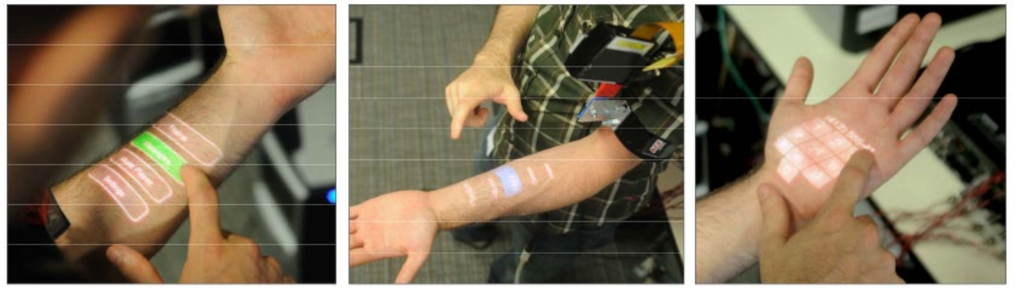


Figure 5. Prototype armband.



Harrison, C., Tan, D., & Morris, D. (2010, April). Skinput: appropriating the body as an input surface. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 453-462).

Machine Learning in UI

- Eye Gaze
  - Standard web camera, tracks eye movement
  - Eye movement combined with cursor position, predicts location of gaze
  - Slightly lower resolution, but able to reproduce effects of expensive commercial eye tracking devices

Papoutsaki, A., Laskey, J., & Huang, J. (2017, March). Searchgazer: Webcam eye tracking for remote studies of web search. In *Proceedings of the 2017 Conference on Conference Human Information Interaction and Retrieval* (pp. 17-26).

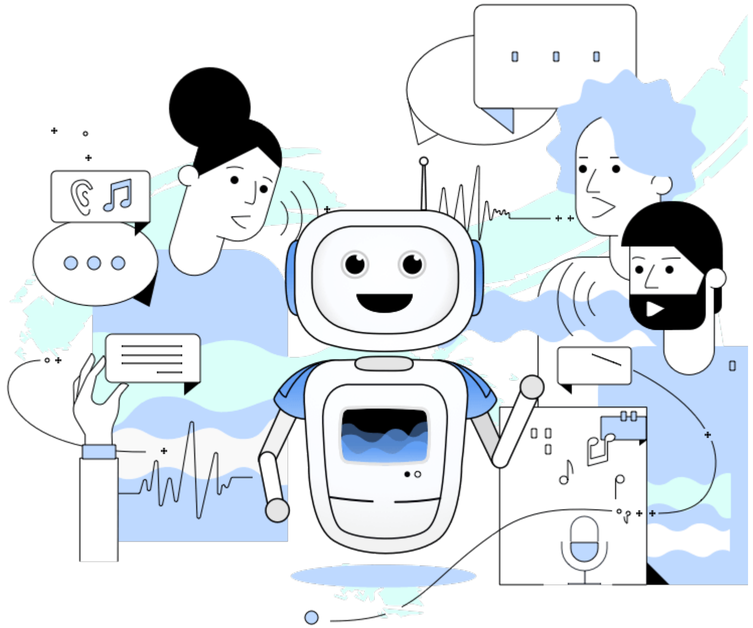
Speech

- Speech
  - It’s complicated!
  - Reserved for organizations large enough to create very large datasets
  - Automatic speech recognition is hard
  - Text-to-speech generation is hard
  - Open source speech engines exist, but they far fall below the quality of services like Alexa and Siri

https://medium.com/react-native-institute/amazon-alexa-tutorial-build-your-own-skill-a83cf71f8aed

Speech

- Common Voice
  - The Mozilla Foundation is working on an open dataset
  - Ask US to help build the dataset by recording preset speech passages



https://commonvoice.mozilla.org/en

Multiple Modalities

- What's wrong with just the keyboard and mouse or a touchscreen?
  - In many cases these three input devices are just fine
  - Accessibility ensures that software is designed with a "common language" that all systems can interpret

Multiple Modalities

- What’s wrong with just the keyboard and mouse or a touchscreen?
  - However…
  - Accessible systems do not ensure efficiency, comfort, or enjoyment
  - We can do better!

Multiple Modalities

- What’s wrong with just the keyboard and mouse or a touchscreen?
  - Offset non-critical tasks with alternatives in UI’s
  - Examples?

Multiple Modalities

- What's wrong with just the keyboard and mouse or a touchscreen?
  - Offset non-critical tasks with alternatives in UI's
  - Examples?
    - Gestures or speech to control – freeing hands to continue work or other tasks
    - Text-to-speech to read the screen
    - Eye-gaze magnification
    - Modal input to increase functionality of existing interactions

Multiple Modalities

- Bridging alternative interactions with touch, keyboard, and mouse, we broaden the ways in which we can control user interfaces

- Alternative interactions can increase usability for people with physical disability, both temporary or permanent

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