Project Ideas

CS486/686

1

Four Types of Projects

- Literature survey
- Implementation
- Algorithm Design
- Theoretical Analysis

- All of the above are fine as long as they are related to Artificial Intelligence

2

Literature Survey Examples

1. How is motion tracking and action recognition done with a depth camera such as the Kinect (Xbox 360)? (computer vision, machine learning)
2. What is the state of the art for computer go (search techniques), computer poker (game theory, machine learning), etc.?
3. How can we detect emotions in speech? (speech recognition, machine learning)
4. How can we automatically classify product reviews/blogs as positive or negative? (natural language processing, machine learning)
5. How are ads selected for advertisement by search engines and other websites (computational advertisement, game theory, machine learning)

3

Xbox 360 Kinect

- Microsoft Cambridge
- Body part recognition: supervised learning

4

Depth camera

- Kinect

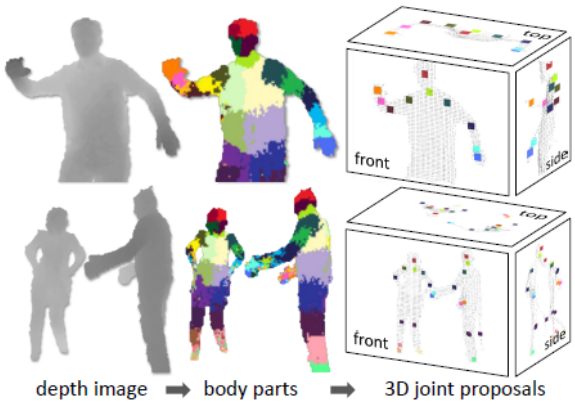
Infrared image

Gray scale depth map

5

Kinect Body Part Recognition

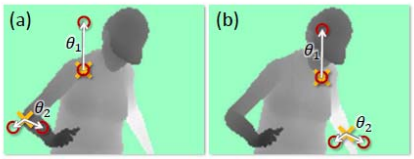
- Problem: label each pixel with a body part



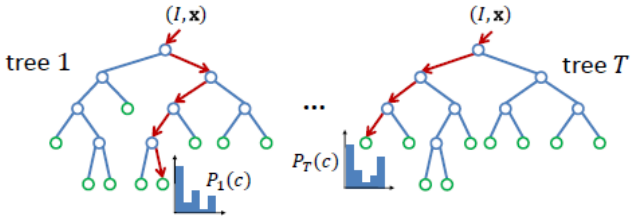
6

Kinect Body Part Recognition

- Features: depth differences between pairs of pixels



- Classification: forest of decision trees



7

Smart Walkers

Instrumented Walker

Forward View

Backward View

8

Smart Walker Sensors

Current:

- 4 Load Sensors
- 2 Wheel Encoders
- 3-Axis Accelerometer
- GPS

Next:

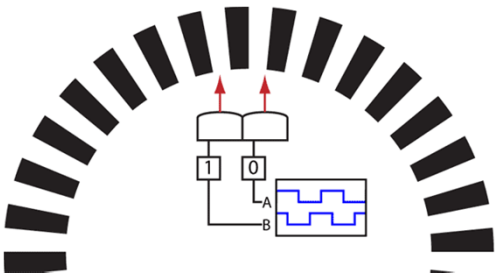
+2 Wheel Encoders

+3-Axis Gyroscope and Compass

9

Wheel Encoders

- Measure wheel movement
  - Sensor generates low/high signals
  - No Directionality
- With two we can infer direction
  - Offset ½ wave
  - "Quadrature"



10

Walker Quadrature Assemblies

- 1st Walker uses wheel embedded magnets
  - Costly and time consuming to install
- New Walkers will use optical encoders
  - Sticker on wheel alternating light/dark
  - Simple sensor
  - Results not as uniform (dust,washout,fading)
- We need to compensate for this!

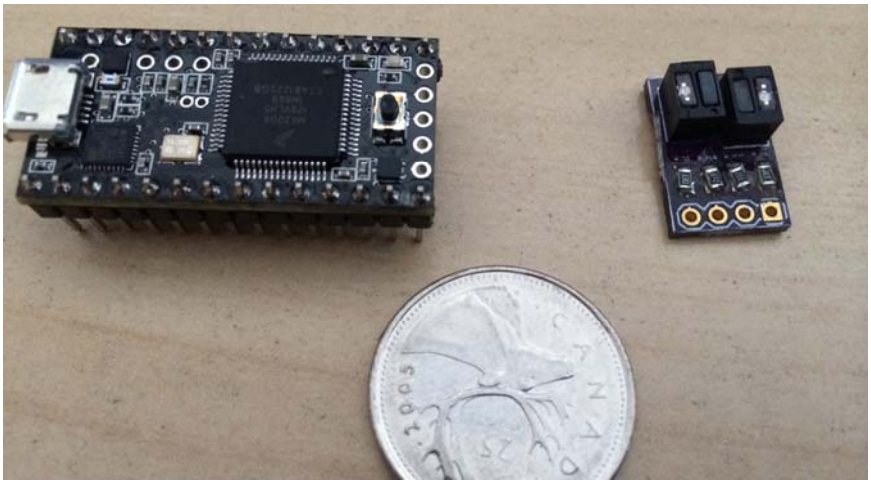
11

Adaptive Signal Interpretation

- With very limited space/processing:
  - Detect changes in min/max values per channel
  - Adapt thresholds for signal being 1/0
  - Warn if signal amplitude wanes too much
- Teensy 3
  - Arduino compatible* microcontroller
  - 32bit arm processor

12

Teensy and Quadrature



13

Another Challenge - Hibernate

- Eventual goal is long term Walker deployment
  - Battery life should be in weeks
- Can we detect periods of low interest
  - Walker not in use
  - Walker used as seat
- Disable high draw devices and polling of them
- Detect when to enable all sensors again
  - Vibration sensor?

14

Smart Phones – Algorithm Design

- Battery Life is a major issue for mobile devices such as smart phones
- Battery depletion rate depends on the services in use (i.e., CPU, WIFI, 3G/4G, Bluetooth, GPS, etc.)
- Two projects:
  - Using Machine Learning techniques, learn a predictive model regarding the usage patterns of services and their impact on battery depletion rate
  - Using decision theoretic methods (Markov Decision Processes and Reinforcement Learning), design a tool to manage services in a way that minimizes energy consumption

15

Sum Product Networks (SPNs)

- New type of probabilistic graphical model
  - Alternative to Bayesian networks
  - **Promising approach for Deep Learning**
  - **Guarantee: exact inference in linear time**
- Several projects that could lead to research papers

16

SPNs – Empirical Evaluation

- Evaluate and compare existing learning algorithms described in the following papers
  - Sum-Product Networks: A New Deep Architecture
    homes.cs.washington.edu/~pedrod/papers/uai11a.pdf
  - Discriminative Learning of Sum-Product Networks
    books.nips.cc/papers/files/nips25/NIPS2012_1484.pdf
  - Greedy Part-Wise Learning of Sum-Product Networks
    ecmlpkdd2013.org/wp-content/uploads/2013/07/498.pdf
  - Learning the Architecture of Sum-Product Networks Using Clustering on Variables
    books.nips.cc/papers/files/nips25/NIPS2012_1012.pdf

17

SPNs – Algorithm Design

- Design new machine learning technique with better performance guarantees than existing ones
- It may be possible to design algorithms that scale better while avoiding local optima based on
  - **Spectral learning or**
  - **Moment matching**
- Talk to Pascal for more details

18

SPNs – Theoretical Analysis

- The relationship between sum product networks (SPNs) and Bayesian networks (BNs) is not well understood
  - All SPNs can be converted into BNs in polynomial time
  - Some BNs can be converted into SPNs in polynomial time
- Project: **characterize the class of BNs that can be converted to SPNs in polynomial time**

19

Moment Matching (MM)

- Moment matching refers to a general machine learning approach where the parameters of a model are set by matching the moments of the model to empirical moments of the data
  - **Promising approach to circumvent local optima**
- Several projects that could lead to research papers

20

MM – Algorithm Design

- **Design a new moment matching technique for an existing model**
- Some models that could benefit from MM include
  - Bayesian networks
  - Sum product networks
  - Mixtures of Gaussians (clustering technique)
- Talk to Pascal for mode details

21

MM – Theoretical Analysis

- Some properties of MM are not well understood
- For instance, suppose that an infinite amount of data is generated from a Naïve Bayes model. **Under what circumstances is MM guaranteed to recover the correct parameters of the Naïve Bayes model?**

22