

ROBOTS FOR RECYCLING

The first weeks of AMP Robotics

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(Team **AMP**)

Boulder is for Robots Meetup
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C&D MATERIAL RECOVERY

A massive-scale problem

- 250 million tons created / year (vs. 500 million tons municipal waste)
- 95% is recyclable
- Today, only 30% is recycled



A 160 million ton/year opportunity...in a \$4B/yr market

RECYCLING PICKLINES TODAY

The current paradigm for construction and demolition (C&D) debris

Hazardous:

- Lead-based paint, asbestos, particulates, sharps
- In a work population of 16,000, 3,000 injury/illness reports/year

Employee retention often a problem.

Cost/benefit:

- Wages + liability insurance dominate recycling costs
- Existing automation equipment must be financed (bonds)
→ final cost often 4x upfront price



For these reasons, most C&D material is landfilled.

ROBOTS FOR RECYCLING?

A good **automated solution** would make C&D recycling **cost-effective**.

Requires solving these problems:

- Object detection
- Multi-tracking
- Classifying debris
- Path planning
- Fast sorting

Must be done **safely** in real time, in a dirty environment, inexpensively.



This is a brief story of our 14-week-old startup and our progress toward these goals.

AMP ROBOTICS

The current team

Matanya Horowitz (founder)

Envisioned this startup as a PhD student



James Bailey (co-founder)

Former Googler, left in search of adventure



Andrew Adare (co-founder)

Defected from academia (nuclear physics)



OBJECT PERCEPTION

Microsoft Kinect v2 for Xbox One

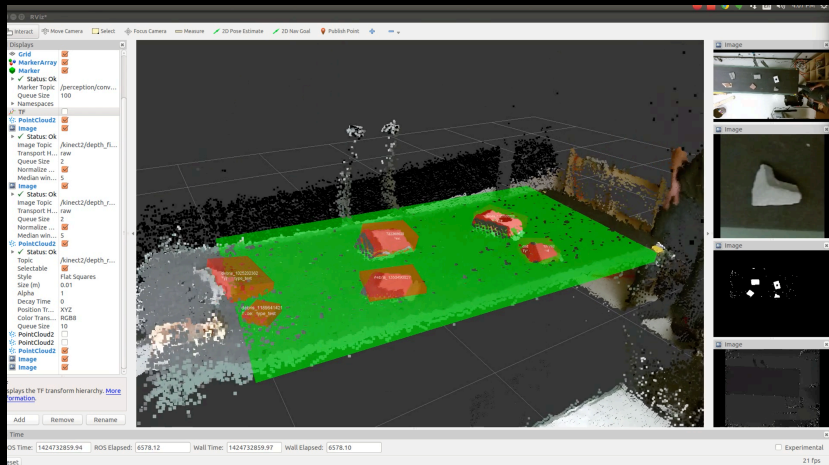


EXIT



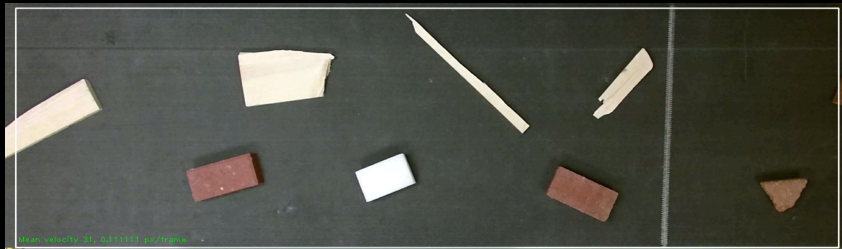
OBJECT PERCEPTION

Segmentation using depth imaging



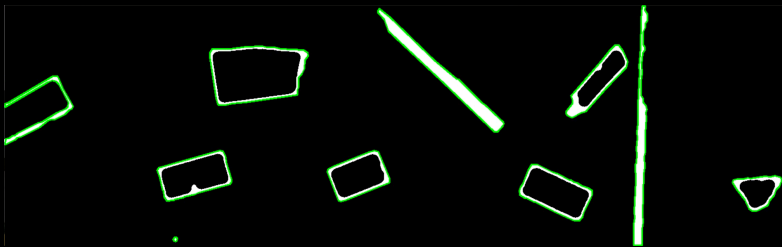
OBJECT PERCEPTION

Color image → edge detection → contours → convex polygon



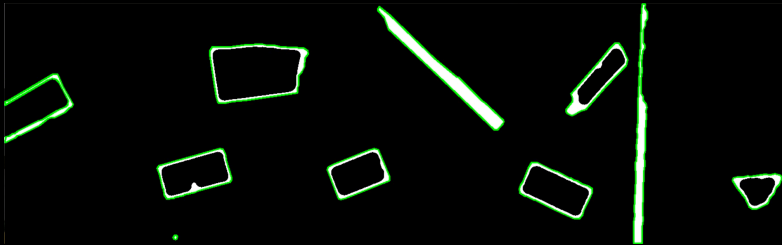
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Ongoing work:

segmentation against a nonuniform background (piled debris)

TRACKING

Multiple objects, noisy position measurements

Animation requires Adobe Acrobat PDF reader

TRACKING

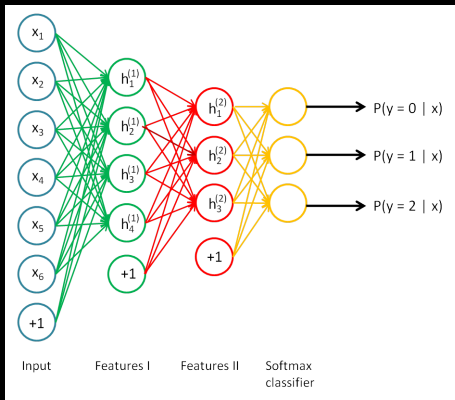
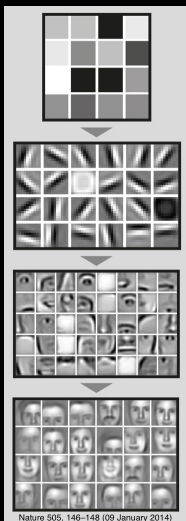
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IMAGE CLASSIFICATION

using deep neural networks

- Given good data, classification is easy
- But learning distinctive features is hard
- Huge advances in the past 5 years

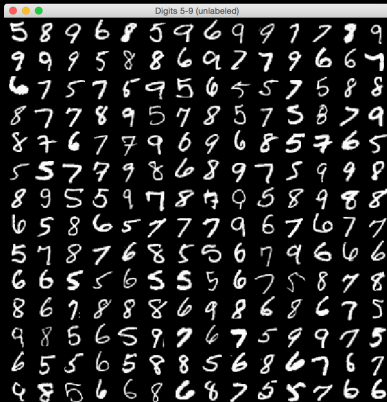


SELF-TAUGHT LEARNING

An example with handwritten digits

<https://github.com/andrewadare/uflidl-tutorial.git>

Show the network images of digits
5-9, but don't tell it what they are



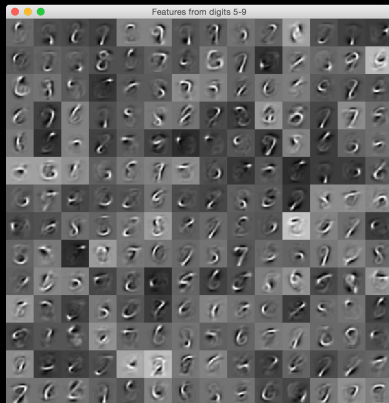
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We do similar things with brick, wood, concrete, etc.



Dataset



Dataset

Classification demo video:

<https://drive.google.com/file/d/0BzdQPu125VBJcnd4a3dMeldBZHM/view?usp=sharing>

PATH PLANNING

Making the most out of simple hardware

Selective conveyor sorting possible with a 1D passive gantry pusher.

Weave through obstacles by solving a 2D boundary problem:

$$0 = -\frac{1}{\lambda}q\Psi + f^T(\nabla_x \Psi) + \frac{1}{2}Tr((\nabla_{xx} \Psi) \Sigma_t)$$

No if statements!

Real-time solution → optimal path in 20 ms

M. Horowitz et al, IROS 2014 224-231 / arXiv:1409.5993



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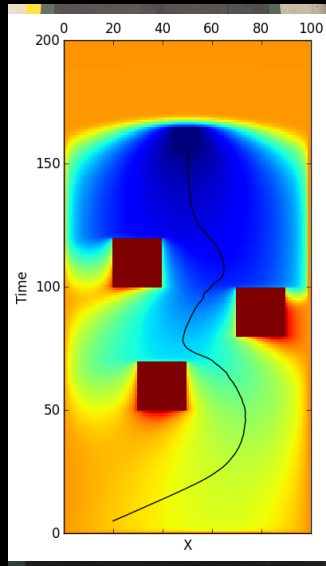
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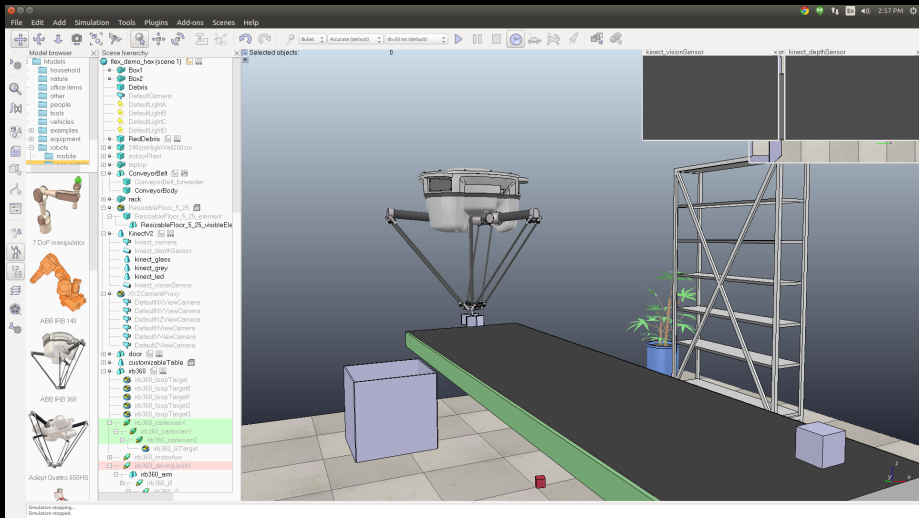


Pusher prototype video:

<https://drive.google.com/file/d/0BzdQPu125VBJUkZoQ3laWXE2VjA/view?usp=sharing>

WHERE WE ARE HEADED

Fast Delta Manipulators



Simulations already underway, acquisition by summer 2015

SUMMARY

- Automated recycling: many interesting problems to work on
- Just getting started, but very optimistic
- Our tech generalizes—enthusiastic about new applications

p.s. We are hiring!

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