Pick and Place Robotics in ROS
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Overview

• What's the problem
• What we're doing
• How it works
• Lessons from manufacturing world
• Pain points
Surface Mount Device Printed Circuit Board (SMD PCB)

About the size of a grain of rice
How people think these things are made...

"ASIA"
How it really happens
Hand Prototyping

- Error prone
- “Like driving the 101 at rush hour”
- Time consuming and expensive
Contract Manufacturer

- Slow and/or expensive
- Research and contracting overhead
- Design file massaging by engineers
What it is?

- XYZ Gantry with dedicated motion controller
- Headless uITX PC running ROS/Ubuntu
- End Effectors: dual pick tips
- Two cameras for feedback
- No feeder mechanisms – cut tape
A bit of background

• Working on this a little over a year.

• First three iterations all in Meteor/JS/Python

• In June we said, this robot needs to be smarter.

• Now pure python and C++ in ROS
How does it work?

- Export your design file.
- Robot looks for parts and board fiducials
- Validate the design.
- Picks up each part.
- Inspects it to correct position orientation
- Place it.
Movie Time
TinyG – Motion Controller

OPEN HARDWARE AND SOFTWARE!!!
TinyG

- Talks over serial over USB
- Speaks gCode and mCode wrapped in json
- Does real time motion control on the fly
- Allows for control of velocity, jerk, etc.
How we use TinyG

- Implement a subset of gcode and mcodes in a python wrapper
- All gcode commands are synchronous, KISS
- Robot runs g codes as ROS service.
- Robot publishes state updates a 50Hz
How it works

- Front End Control
- Build Utilities
- Boss Node
- Manager
  - Action Server
    - Scan PCB
    - Scan Parts
    - Pick Component
    - Inspect Component
    - Place Component
    - AOI
- Bottom Camera Node
- Top Camera None
- TinyG Node
Computer Vision

- Custom message with part/tape description
- Includes tape type, part dimensions, package, etc
- Lots of multi-level detection. E.g. find tape “wells” then part.
- All CV is keyed on part data for top and bottom with catch all generics.
- Mostly written in pure python so we can pop data into and out of ipython
- Strategy allows us to create a database of custom part data.
End Effectors
User Interface

- Original robot was all web based and headless

- THIS IS THE WAY FORWARD

- Linux, OSX, windows, whatever...

- Looking forward to really working out robot web tools.
This is a process – lots of lessons

Mark I

Mark II

Mark III
Engineer Cost Last: Cameras

$30

Cheap DIY ring light.

$300
Engineer Cost Last: Computing

BeagleBone Black

MiniITX

Minnow Board Max
Lesson: we have a shop for that

- Network to find people and places for every task
  - Sheet Metal
  - 3D Printing
  - Powder Coat
  - Machining
  - Acrylic / Plexi
  - Same day parts
  - General Labor
  - PCB / CM

- Track lead time, suggestions, contact, price.
Cabling can kill you.

- Label everything – both end
- Cable braiding / binding / harnessing
- Solid core versus stranded
- Right gauge for the job
- Strain relief: electrical connections != mechanical connections
- Build break out boards.
- Wire to wire connectors for serviceable parts.
- Minimize the items in your BOM
- Track everything in your BOM
Lesson: Play Well with Others

- Building the robot is easy
- Getting data into the robot is hard.
- CAD standardization is a mess
Lesson: Modularity Reduces Scope
Current Pain Points for Manufacturing

- Getting data out of CAD
  - Yes there is open source...
  - But industry doesn't use open source.
- This is not just EECAD
- Similarly industry PLC buses are lacking (modbus, profibus)
- Minimal Standardization
- Huge supply of useful data.
Current Pain Point – Data

- Bagging in ROS is incredible.
- But...
- Bagging is not a database for web persistence, QC, or learning over LONG times.
- Database would be swell
  - Archive information, particularly binary
  - Search through the binary and data
  - Play with data in iPython
  - Spin up roscore squirt data to a node / simulator
Industrial 3D at Micro Scale

- Depth sensors are great, and our application could benefit from them.
- Nothing works at the sub mm level.
- Need high accuracy stereo
- Structured light / laser scanning.
Plugs

- Come help us
- Prototyping ROS hardware?