Adventures in
(relatively)
Affordable 3D Printing with Monoprice Printers

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for Robotics Society of Southern California

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Hi, I’m Roger

- Past life: Software developer in closed-source platform, can’t talk much about it to people outside of workplace.
- Current life: Learning about hardware and open-source technologies, participate in communities, and share knowledge via public speaking.
- Last month at RSSC: Sawppy the Rover, a 3D printed motorized model of Mars rovers Curiosity and Mars 2020.
- Today: The 3D printing journey behind Sawppy.

Take Everything With a Grain of Salt

- This is true of internet in general, and it is true of 3D printing information online.
- The internet is full of information, much of it contradictory.
- Distinguishing fact from fiction, signal from noise, can take a lot of work.
- I’m here to share what I know, but what I know might be wrong.
- We will advance our collective knowledge together!

A Tale of Three Printers

- Monoprice Mini
  - ~$150

- Monoprice Maker Select
  - ~$300

- Monoprice Maker Ultimate
  - ~$600

Why These Three Printers?

- When I started exploring 3D printing, they were the low/mid/high offerings in Monoprice product range.
- They are among the most affordable 3D printers that were fully assembled from a retailer with a track record.
- Printer kits can be cheaper, but we supply the labor for assembly.
- Buying from random retailers can be cheaper, but they may or may not exist next month.

- Most 3D printers are far more expensive. How does Monoprice do it?

Monoprice

- Local company based in Rancho Cucamonga.
- Manufacturing done overseas by other companies.
- Products are made to Monoprice specifications.
- Imported in quantities that fill shipping containers.
- Sales and distribution from warehouse to consumers.
- Local consumers like us have option to pick up from warehouse.
  - How much are you willing to pay someone else to drive across LA?

Monoprice Cables

- Friends Don’t Let Friends Buy Monster Cable.
- Early years of HDTV had ridiculous margins on HDMI cables.
  - Promoted by retailers like Best Buy, because they get a big cut too.
- Monoprice executes textbook free market economics.
  - Contracts with some of the same Chinese factories as others.
  - Place high volume orders for cables of equivalent or better specifications.
  - Sell for lower margin than Monster Cable.
  - Profit!
- But others soon caught on. (See: textbook free market economics.)

Monoprice Expands

- Need to venture beyond cables.
- Leverage existing industry connections, import other goods.
- Computer monitors
- Home audio: speakers and amplifiers.
- Mobile audio: headsets and microphones.
- Music instruments… sous vide cookers… outdoor and camping?
- Sometimes find a new market niche success, sometimes not.
- 3D printer is one of the more successful niches.

Monoprice 3D Printer Origins

- Result of the same Monoprice formula.
- Different printers may be made by different companies.
- In the US, printers may be available under “original” name but not much cheaper than Monoprice due to their sales volume.
- Cheaply built of “good enough” parts.
  - But occasionally not quite good enough.
- Few staff have any expertise
  - Not much tech support, pretty much go straight to RMA number.

Monoprice 3D Printer Advantages

- Low price + high volume retailer = lots of printers out there.
- Lots in circulation + lackluster tech support = big internet community.
  - Lots of information available, some of it is even accurate.
- Cheaply built from commodity parts = very easy to modify/upgrade.
  - And if you break it… they're cheap. Buy another!
- Low price = why have just one?
  - This comes in handy when we need one to print replacement part to fix another.
  - 3D printing enthusiasts rarely have just one printer for this reason.

Monoprice 3D Printer Purchase Tips

- Never pay full price. There's probably a discount right now. And if not, there will be one shortly.
- They have a generous 30 day return window for refund.
- Many products have a one year replacement warranty.
- Go on the internet for technical support, not Monoprice.
- Contact Monoprice support for return or exchange.
- Want an adventure? Buy "Open Box" or "Refurbished"

Monoprice Select Mini

- Monoprice branded Malyan M200.
  - The closest thing to a Fisher-Price “My First 3D Printer”
- Small print volume: 120mm cube
- But quite capable at breakthrough price.
- All the same fundamental concepts as bigger printers.
- Easy to find space for the compact printer.
- Small lightweight print head delivers good detail.
- Good enough to tell if 3D printing is for you.

Monoprice Select Mini Design Tradeoffs

- Single fan for both heat break and print cooling.
- Small motors on X and Y axis can’t move very fast.
- Cheap Z-axis construction introduces print artifacts.
  - Varies from printer to printer.
- Heated print bed is good, thin print bed is not.
- Lacking features for long-term durability.
  - Lack of strain relief for some wiring.
  - Plastic extruder lever arm known to break.
- Low power heater is a blessing and a curse.

Monoprice Select Mini Personal Experience

- Cooling fan bearings are not designed to be jerked around.
  - After a few months, started to fail and make a buzzing noise.
  - New fan adapter was first “3D printer fixes itself” project.
- Z-banding proved problematic for mechanical parts.
- Print bed became warped under stress, became impossible to level.
- Caught the 3D printing bug, want bigger and faster prints.
- Lots of people upgrade their mini – some beyond all recognition.
- Decided I rather spend the money on another printer.

Monoprice Maker Select

- Monoprice branded Wanhao Duplicator i3.
- Trace lineage back to open source RepRap Prusa i3 by Josef Prusa.
- Simple bolt-together construction for easy upgrades.
- Many hobbyist level 3D printer use this general design.
- Easily adapt modifications and upgrades.

Monoprice Maker Select Over Select Mini

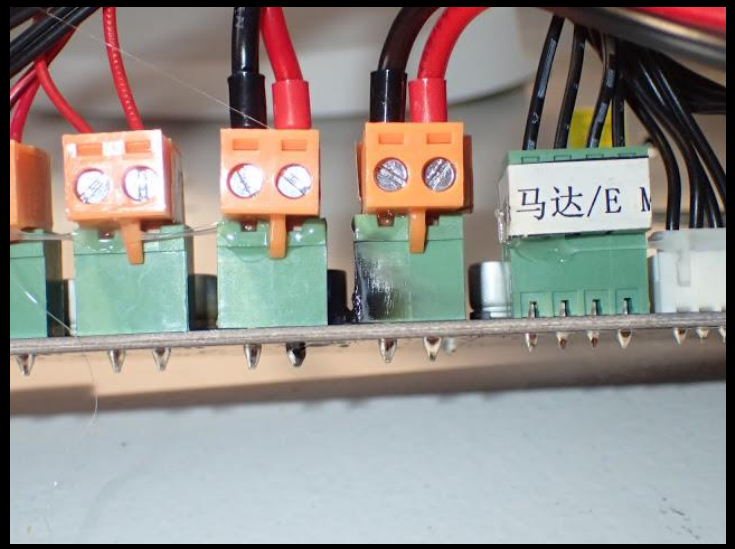
- Significantly larger print volume 200mm W x 200mm D x 180mm H
  - 7200 cm^3 vs. 1728 cm^3, over 4X increase.
- Separate heat break and print cooling fans.
- Thicker print bed more resistant to warping.
- Precision Z-axis means no more Z-banding. Hooray!
- More powerful heaters
  - Higher temperatures are possible.
  - Warm up to temperatures faster.

Monoprice Maker Select Weaknesses

- Still made of thin sheet metal and prone to flex.
- Heavier print head has more inertia.
- Print at high speed exhibits problems controlling this inertia.
  - “Ringing” and other terms.
- Control box design and wiring takes up a large footprint and very awkward to move.
- Memory card slot is annoying.
- Controller UI is primitive plus infuriating push dial.

Monoprice Maker Select Goes Up In Smoke

- 5 days past 30 day refund window, control board failed.
- It was during initial warmup, maximum power to all heaters.
- No visible flame, but my room was filled with smoke.
- Control screen went blank and responsive.
- Internet search says it is a common problem.
- New enough I submitted for replacement.
- None in stock, accepted offer for store credit.
- This was an unplanned upgrade.



Monoprice Maker Ultimate

- Monoprice branded Wanhao Duplicator i6.
- Internet wisdom says “inspired” by Ultimaker.
- Rigid aluminum chassis.
- Complex control geometry.
  - Many more belts and shafts distributes load.
  - Z-axis drops print bed (vs. raising print head.)
- Better movement precision.
- Easy addition to enclose print volume.
- X/Y Motors move faster than plastic can adhere.

Monoprice Maker Ultimate Experience

- Good design overall. Only gripe is print cooling.
- Over 10 months of mostly reliable service.
  - Bushing fans failed, replaced with ball bearing fans.
- No smoke, but motors and fans stopped working mid-print.
- Time to hit the internet!
  - Most common cause: failed relay.
  - Confirm relay failed.
  - Technically within 1 yr. exchange.
  - Decided to replace relay myself.

Successful Repair Was Encouraging

- Started thinking about making upgrades to my printer.
- Maker Ultimate is not very upgrade-friendly.
- Select Mini is just so small.
- New plan:
  - Keep Maker Ultimate in default configuration.
  - Get a Maker Select to explore upgrades.

Monoprice Maker Select (Refurbished)

- Since I’m planning to void the warranty anyway, why buy new?
- Refurbished for under $200, close to price of a new Mini.
- These are printers people have returned.
- Then refurbished (or so they say) for resale.
  - Monoprice staff are not 3D printing experts.
  - Out of 5 sample points, only 2 printed flawlessly out of the box.
- Now sold as “Open Box” which is more accurate.
- Would not recommend “Refurbished” or “Open Box” as first printer.
- Great for those seeking a project.

Who Performed Refurbishment? Me!

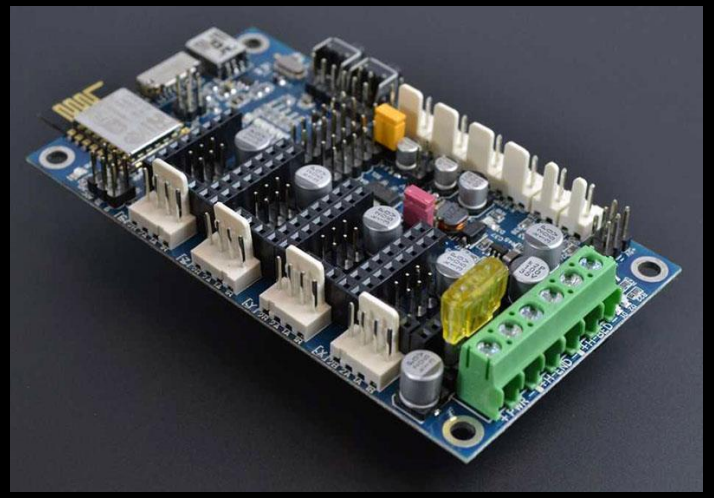
- All axis moved on command but would not print.
  - Nozzle was clogged
- Print bed was well worn, replaced with sheet of PEI.
- Belts were loose and needed to be tightened.
- Y-axis pulley was misaligned – unknown if poor initial assembly or poor modification work.
- All of the above were easy to fix thanks to design of printer.
  - But a beginner would not have known where to look or what to do.
- Now it prints, though somewhat poorly due to uneven extrusion.

OctoPi: First Functional Upgrade

- OctoPrint: A web-based interface for controlling 3D printers.
- OctoPi: A Raspberry Pi dedicated to run OctoPrint.
- Bypasses poor microSD slot and poor control dial.
- Tracks and manages print jobs over the network.
- Allows remote monitoring via webcam.
- Extensive plugin infrastructure (I did not explore.)
- OctoPi is nice, but just a luxury for a well built printer.

Azteeg X5 Mini: New Brain

- Soon my old nemesis returns: I smelled the scent of unhappy electronics. Is this one going to fill my room with smoke again?
- Replaced control board with Azteeg X5 Mini
  - Far higher power handling capacity.
  - More flexible configuration options.
- Best part of upgrade: near silent motor operation.
  - Very important when I'm in the same room.
  - (To make sure it does not set my house on fire.)
- Skipped optional control panel – I have OctoPi.



Ambition to Print PETG Plastic

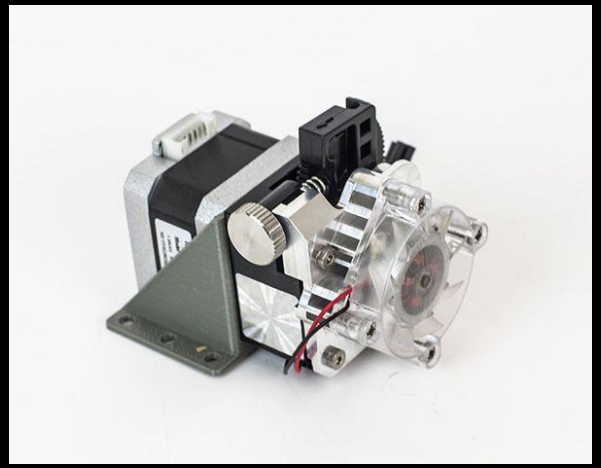
- Up to this point I've been printing with PLA plastic.
- Easy to print, rigid, but also brittle.
- Unfortunately also means PLA softened under SoCal summer sun.
- PETG is less rigid, more ductile, and will not soften under sunlight.
- But it also means more heat is required to melt it for printing.
  - Default print head has to slow way down to melt PETG.
- Layers would not stick unless I turned off cooling fan.
  - Guessing layers need more time to meld into previous layer.

All-Metal Hot End

- In order to transfer heat to PETG faster, need to switch to all metal hot end.
- Downside: will not print PLA as well.
  - Decided this is OK – my Maker Ultimate can handle PLA prints.
- Easy screw-in all-metal replacements to default hot end.
  - Does not require control board modifications.
  - Can swap back and forth as needed.

E3D Titan Aero: New Business End

- Intermittent under-extrusion has been vexing.
- E3D Titan Aero is an integrated extruder and all-metal hot end.
- Solve both problems with a single upgrade.
- E3D Titan Aero is not a direct replacement.
  - Requires more wiring work.
  - Requires changing control board configuration.
  - Thankfully Azteeg X5 Mini is each to modify.
- Successfully printed all major parts for Sawppy the Rover in PETG.



Current State of my Printers

- Monoprice Maker Select
  - Extrusion rate is finally consistent.
  - Can now print PETG at acceptable speed.
  - Dimensional accuracy still poor, but that was intentional part of Sawppy test.
- Monoprice Maker Ultimate
  - Replaced cooling fans and main relay.
  - Otherwise stock and printing PLA at high speed.
- Monoprice Select Mini
  - Loaned out to others as their first 3D printer.
  - Temporarily recalled for this talk.

Current State of Monoprice 3D Printer Line

- Many more products have been added
- Select Mini has been upgraded and moved upscale.
- Mini Delta is the new entry level offering.
- Delta Pro takes the high end.
- Has Maker Select been upgraded to avoid smoke? I have not heard.
- Maker Ultimate upgraded with beefier relay and better cooling.
- New printers with larger print volumes.
- New printers with enclosed print area.
- Expanding into field of resin printers.

Based On My Experience…

- Monoprice Maker Mini
  - Highly recommended as inexpensive My First 3D Printer.
  - But be prepared to move on to continue with 3D printing.
- Monoprice Maker Select
  - Would not recommend as first printer.
  - Recommended “Open Box” for people who want to tear into 3D printers.
- Monoprice Maker Ultimate
  - Not a bad choice, but many other good ones at similar prices.
  - Consider a Prusa i3, support an original inventor.

Based On Spec Sheet...

- Monoprice Mini Delta
  - Possibly an even better start to 3D printing.
  - Auto-calibration eliminates big headaches.
  - A handle on top makes it explicit: this is designed to be portable.
- Monoprice Delta Pro
  - Silent motor drive is very compelling.
  - Too large to be easily portable, though also has auto leveling.
  - Price is high enough to face many other competitors.
- Monoprice Maker Pro
  - Large volume is nice in concept, but usually have accuracy tradeoff.

Questions / Comments / General Discussion

- You are invited to come take a closer look at the printers.
  - Including some original parts from the Maker Select.
- I also have print samples for detailed examination.