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THE AGE OF DIY AND DAWN OF THE MAKER MOVEMENT

HELLO, WORLD!

We live in interesting times. While people have been "making" things for quite a while, the last few years has seen the emergence of a distinctive maker and DIY ("do-it-yourself") culture all around the world. One interesting facet of the maker culture is its pervasiveness. One does not need a PhD or professional license to be a part of this culture. It is pop culture at its finest! The cost of building a small, interesting robot today is really only a few hundred US dollars. A decent 3D printer can be built for under five hundred (not including ink). There are reasonable digital oscilloscopes that fit inside a watch or plug inside your PC. The precipitous drop in cost of materials and equipment, along with the widespread dissemination of knowledge via low barrier mediums like online videos and the web have all had a hand in making "DIY" easier than ever before.

At the heart of the maker world is a collaborative community spirit, whether it is about sharing designs, working collaboratively in a shared space (a.k.a. "hackerspaces"), raising funds from a broad community of interest, or showing off your cool project at venues such as Makerfaire. The community of makers utilizes traditional manufacturing techniques (e.g., wood- and metal-working). The special twist is that one does not need to go through an apprenticeship process and commit to years of study along with a vocation.

Rather, one can simply find the closest hackerspace and join up or organize a course on PCB ("Printed Circuit Board") design, soldering, or forging pendants by melting discarded coke cans. In addition, there are some enabling technologies – single board microcontrollers and 3D printers - that became popular among the hobbyist communities over the last few years. These are distinct faces of the maker community. Finally, there are a plethora of applications that the maker community is interested in. This changes over time but recently, there is great interest in small robots, flying drones and quantifying one's daily routines and habits. In this piece, we'll be exploring some of these broad trends.

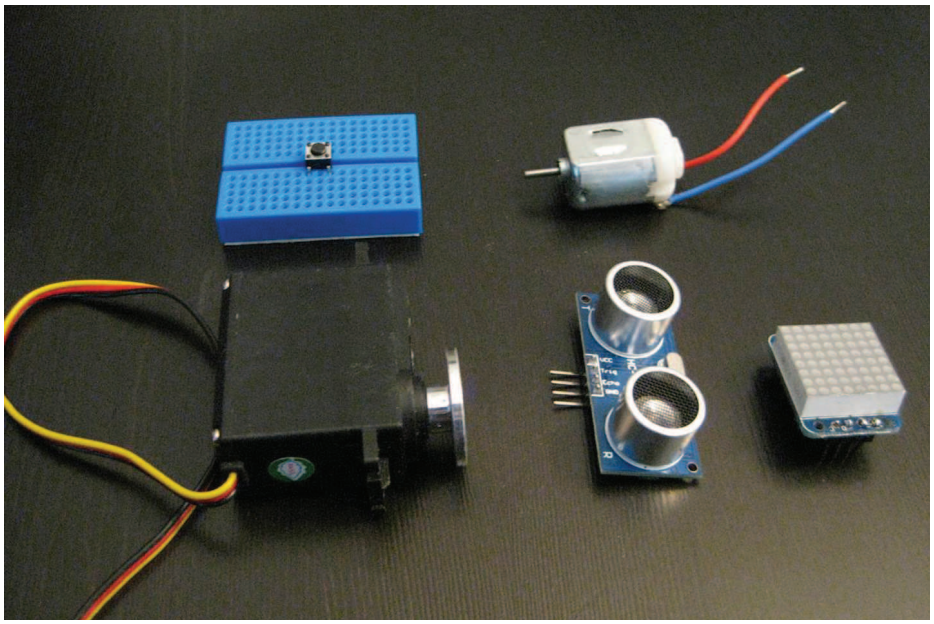
BRIDGING THE CYBER-PHYSICAL WORLDS

If one turns the clock back just a few years, we encounter a world where a lot of effort had been expended to make software more accessible to non-specialists. However, this was certainly not the case for hardware. In 2005, the Arduino single-board microcontroller made its debut and did much to lift the shroud of complexity around hardware. It allowed makers the world over to create projects that interfaced with a variety of sensors and actuators, glued together and orchestrated with software. The Arduino was special for a variety of reasons – it was low-cost, its designs were open source, and, most of all, it was easy to use. Arduino's creators provided an IDE ("integrated development environment")

that came pre-baked with many example programs and they spent considerable effort on providing a web site that taught the basics to non-specialists. These were some of the factors that encouraged a large, fervent community of makers to form around the project. For this generation of makers, hardware was no longer a black box.

In a short time, the community "forked" the original design and created variant form factors (e.g. mini versions, a variant that could be sewn onto clothing, versions that integrate into the chassis of small robots), and also created expansion boards that interfaced with specialized chipsets (e.g. wifi, Bluetooth Low Energy, LCD displays).

While the Arduino holds a hallowed place in the maker movement, it is certainly not alone in its innovation. In 2012, the Raspberry Pi project was released and immediately achieved much success. The goal of the Raspberry Pi was to bring a basic, low-cost computer to the masses in order to allow teaching of computer science and programming concepts. This was achieved by creating a single board computer that ran a low-cost ARM processor and utilized common computer peripherals. Early versions had processors under 1Ghz and 256MB of RAM. However, this was done at an impressively low cost - under $35 USD! Again, a community of enthusiasts took off and started creating instructional material, software and even cases to house the device. Another interesting aspect of the Raspberry was its inclusion of GPIO ("general-purpose input/output") pins that allow interfacing with sensors and actuators just like the Arduino and related microcontrollers (however, when the Raspberry Pi is used, programs are written in a high-level language such as Python and utilize the Linux operating system). This design choice has made the Raspberry Pi a popular enabling technology for the projects of makers worldwide.

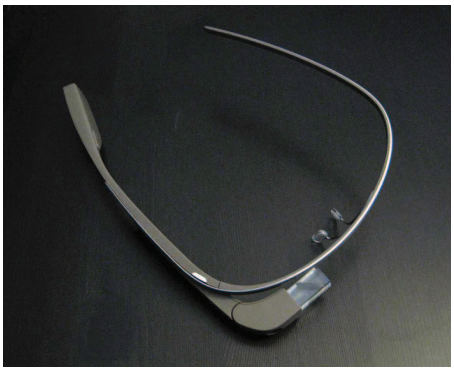


Various sensors and actuators that can be easily programmed by boards such as Arduino.

3D PRINTING

Another project that was getting underway in 2005 was the RepRap, whose stated goal was as ambitious as the core plot device of a great sci-fi book - creating a machine that could self-replicate. The technique used in this project is called "fused filament fabrication", an additive manufacturing technique. One could simplify it as saying you make things by melting plastic one drop at a time. While ambitious, members of this project were fairly pragmatic as the first few versions of the RepRap aimed to replicate only some parts of the machine. The RepRap project was also open source and benefited from a global community of experimenters building, testing and refining ideas. Over the years, the RepRap went through several iterations. In 2009, some members of the RepRap community founded MakerBot industries and they achieved much success in bringing low-cost, 3D printing technology into the homes of makers worldwide.

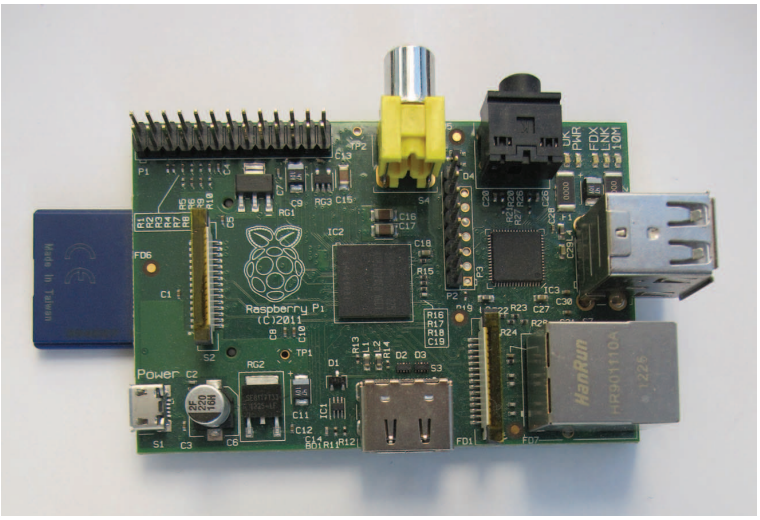
The project had humble beginnings to be sure – wood panels for early versions were cut using a lasercutter at a community hackerspace in Brooklyn called NYC Resister, and, for long time, an enthusiast could save money by buying a MakerBot that was a kit that they would have to assemble themselves. Ultimately, the 3D printers turned out to be a hit and one might argue that to a large extent, the incredible success of the various MakerBots was because of the focus on ease-of-use. Each successive version of this 3D printer seems to have tried to integrate features that make printing 3D objects almost as simple as printing documents using a printer.

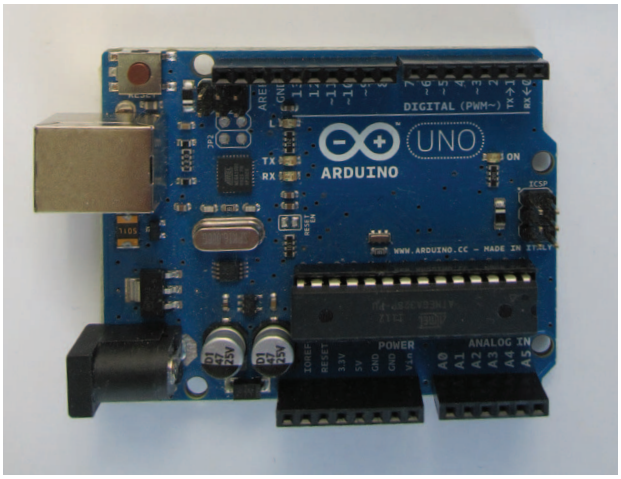


Google Glass, a modern take on wearable computing.

FINANCING YOUR PROJECTS IN THE DIY WORLD

The concept of microfinance may have its roots in antiquity but its modern popularization is usually credited to Muhammad Yunus of the Grameen Bank of Bangladesh. The key idea is that economic and social development objectives can often be achieved by giving lots of small loans to people who would otherwise not have access to institutions that give credit. In the mid-2000s, the concept got turned on its head by websites like Indiegogo, Kickstarter and others,





Affordable circuit boards that enable physical computing. The board with the yellow video adapter is the Raspberry Pi, which can boot various Linux distributions. The board on the opposite side is the Arduino Uno, which allows users to create small programs (called sketches) and has been extremely popular in the Maker Movement.

whereby makers with ideas could raise funds to realize them via crowdfunding. Several variations of the concept exist, but a common scenario remains: "a maker creates and iterates through some designs and prototypes of a widget."

They have no idea how big the potential market for their widget is. Also, economies of scale give rise to the fact that producing more units of a widget costs less per unit than fewer units. Enter crowdfunding – the maker puts up a description of their idea often alongside videos and other details about their prototypes. A community of enthusiasts who want the widget to exist can pledge money towards its creation. Almost always, such crowdfunding campaigns provide rewards to backers[1] and if a target amount is not raised, the project does not go ahead and the backers get their money back. This model has proven immensely successful and has made it possible for makers to productize their creations without resorting to traditional mechanisms of financing, marketing and product distribution.

APPLICATIONS

To list or even attempt to taxonomize all of the various creations by makers worldwide would be a herculean task. Some broad application categories exist however, and we will describe a few exemplar projects in each category.

First off are projects that help educate children or novices, more generally. A recent entry in this area is the littlebits project, in which individual electronic components (such as light sensors, push buttons and motors) can snap together using magnets and can be combined to create interesting devices. Not only is there a community of designs available freely online, the creators of littlebits chose to open source the design of the various modules themselves.

Another category that is filled with examples is robots and airborne drones. Projects strive to provide parts and chassis for all manner of low-cost robots. There is also a community of software enthusiasts that provide libraries for controlling and coordinating robots. At the recent SolidCon 2014 conference, one of the keynotes showed a Clojure-based library that made a Sphero, Roomba and AR Parrot drone "dance" together, in concert, on stage. Closely-related is the category of 3D printers. At the last Makerfaire we attended, we counted no fewer than a dozen different 3D printer designs. What is interesting is that the community is evolving rapidly. Rather than the fused filament fabrication technique described earlier, some newer designs utilize stereolithography[2], and promise better-quality outputs. Last, but not least, are sensors of every kind. Makers have created sensors that track moisture in the soil and automatically actuate a water pump. There are also some interesting sensors that plug into the OBD ("on-board diagnostics") port of newer model cars and provide a phone "app" that lets one monitor various diagnostic values emitted by their vehicle. There are all manner of sensors and actuators that can be sewn onto clothing utilizing components such as conductive threads. Indeed, e-textiles is rapidly becoming a distinct community of makers. ■

[1] There are sites such as Watsi that do crowd-funding for donations and these operate a bit differently.

[2] A process by which liquid plastic resin is hardened into physical form using specific wavelengths of light

REFERENCES

[1] E. S. Raymond. *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*. O'Reilly & Associates, Inc., Sebastopol,CA, USA, 2001.