3D printable PV components literature review

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RepRap Technology

RepRap - the replicating rapid prototyper


Abstract:

This paper presents the results to date of the RepRap project – an ongoing project that has made and distributed freely a replicating rapid prototyper. We give the background reasoning that led to the invention of the machine, the selection of the processes that we and others have used to implement it, the designs of key parts of the machine and how these have evolved from their initial concepts and experiments, and estimates of the machine's reproductive success out in the world up to the time of writing (about 4500 machines in two and a half years).

Notes:

- Give history of RepRap
- Started in 2004
- First RepRap self-reproduction in 2008
- Originally designed to print ABS
- PLA chosen as an alternative print material as it is plant-based and biodegradable
- 48% self-replicating excluding fasteners, 13% including fasteners (For both Darwin and Mendel)
- Mendel possible self-replication of 57% (excluding fasteners) if bearings are replaced with printed plain bearings.
- From Table 1- Mendel: Cost-350 Euros, Deposition Rate-15 mL/hr, Nozzle Diameter-0.5mm, Positioning Accuracy-0.1mm,

Open Design and the Reprap Project


Abstract:

This paper details the investigation of an emerging trend within technology development: 'open design'. Improvements in communications and computing technology have made collaboration over geographically vast distances possible. This technology has already had a major impact on the field of engineering, from the development of CAD/CAE/CAM practices to the emergence of concurrent engineering. Taking the lead from open source software, open design is an approach to technology development in which technical design information is licensed in such a manner that it can be accessed, utilised, modified and redistributed by anyone. The potential implications of this concept can be inferred from the
impact of open-source software. A review of the existing literature on the subject was conducted. A practical demonstration of the process was undertaken, via an attempt to contribute to an existing open design technology: the RepRap. This is a low-cost rapid prototyper capable of manufacturing the parts required to make a copy of itself. The ability to use resin as a construction material was identified as a requirement of the device. An approach to integrating resin extrusion within the device was selected, a suitable material identified, and an experimental rig designed and assembled. Initial test results indicated that resin extrusion is viable for the RepRap.

Notes:

- Discusses the benefits of "open design" - advancement of technology, the rapid evolution of designs, efficient debugging, ability to deal with uncertainty about a new technologies success.
- Good brief history of the RepRap
- Investigated the possibility of using resins as a feedstock - Used a UV curable adhesive resin
- Created experimental, syringe-based extruder run on a 3-axis desktop CNC machine (not a RepRap)
- Experiments to investigate the feasibility, cure times, the effect of mixing resin with additives, using ABS and resin, and using ABS as a support structure.
- Found that only high viscosity resins produced acceptable print quality without any support structure.
- ABS can be successfully used as a support material in combination with low viscosity resins. It can later be removed by submerging the part in acetone which dissolves the ABS but keeps the resin intact.

An Open Source Hardware-based Mechatronics Project:
The Replicating Rapid 3-D Printer


Abstract:

This contribution reviews the execution of open-source hardware (OSHW) project as part of the Master in Mechatronics Degree Programme at the University of Southern Denmark. There were a number of reasons that motivated us to carry out this project; educational, intellectual, and research reasons. Open source projects provide unique opportunities for students to gain experience solving real-world problems. There was also a research consideration in pursuing an OSHW project. Three of the authors of this contribution are working towards a Master's Degree in Innovation and Business and wanted to carry out an OSHW project as a precursor to doing research work on the 'Commercialization of OSHW Projects'. The choice of the project was all-important and we choose to build a 3-D printer using information provided by the RepRap Open Source Community because this satisfied nearly all our specifications for an OSHW project. Our experiences in constructing a 3-D
printer as well as documenting the areas where the open-source information currently has deficiencies are documented here.

Notes:

- Outlines the history of Open Source Hardware (OSHW) from Open Source Software
- Use of Open Source Appropriate Technology projects in the classroom (cites Dr. Pearce)
- Overview of building their Mendel and the problems they encountered - holes to small, firmware issues, hot end failure
- Printed ABS400 at 260C.
- Hot end problems- had multiple failures of PTFE thermal barrier. Switched to a PEEK barrier.
- Switched from ABS to PLA - had problems with sticking in the nozzle, fixed with oil
- Used Gen 3 electronics
- Described many deficiencies in RepRap documentation

3-D Printing of Open Source Appropriate Technologies for Self-Directed Sustainable Development


Abstract:

The technological evolution of the 3-D printer, widespread internet access, and inexpensive computing has made a new means of open design capable of accelerating self-directed sustainable development. This study critically examines how open-source 3-D printers, such as the RepRap and Fab@home, enable the use of designs in the public domain to fabricate open-source appropriate technology (OSAT), which are easily and economically made from readily available resources by local communities to meet their needs. The current capabilities of open-source 3-D printers are reviewed and a new classification scheme is proposed for OSATs that are technically feasible and economically viable for production. Then, a methodology for quantifying the properties of printed parts and a research trajectory is outlined to extend the existing technology to provide complete village-level fabrication of OSATs. Finally, conclusions are drawn on the potential for open-source 3-D printers to assist in driving sustainable development.

Notes:

- Defines appropriate technology
- Appropriate technology is not well documented and shared. Need for better dissemination.
- Commercial printers have high tolerances but expensive ($5000-$200,000) compared to ~$1000 open source printers
- RepRap and Fab@Home started at colleges and have open source communities
- Self-replication 6.83% with fasteners, 48% excluding fasteners
• RepRap can print ABS, PLA, HDPE, and polycaprolactone
• "Sequential layer deposition"
• Open source CAD software and model sharing on Thingiverse
• No machining skills necessary to operate 3-D printers
• Open source printing would encourage training in CAD and design
• Printed parts could be used in energy, farming, water, food, medical, transportation, handicrafts, housing, and industrial applications
• Possible directly made parts include: prosthesis, tools, gears, clamps, etc.
• Using printed part for making a casting mold
• Post-processing is acceptable for OSAT applications
• Most development in open source 3-D printing is from the hacking community, not currently influenced by the full potential of materials science and engineering
• 3-D printing does not have the reliability or testing for deployment in developing countries.
• More testing of printed parts is need along with development of testing methods to find the properties of printed materials
• Need theoretical analysis and testing of parts to determine the suitability of printing objects.

**RepRap: The Replicating Rapid Prototyper Maximizing Customizability by Breeding the Means of Production**

Z. Smith, "RepRap: The Replicating Rapid Prototyper Maximizing Customizability by Breeding the Means of Production."

Abstract:

Consider the wolves that you see being led down the street every day. Their appearance ranges from the whimsical to the grotesque, and their adult body size covers a span unmatched by any other species. This virtuoso and antic variety were created by one of humanity's oldest and grandest technologies: genetic engineering. We have been customizing life since the invention of agriculture in Mesopotamia around 9500 BCE (Wikipedia, 2007).

Nowadays much of that customisation is done industrially, though the techniques still retain an important characteristic that they have had over the millennia: they can be done by a single person possessing equipment no more advanced than a breeding pen or a potting shed. Even the latest twist of the helix – direct manipulation of DNA – requires modest wherewithal well within the resources of an individual (Dyson, 2006).

**The Intellectual Property Implications of Low-Cost 3D Printing**

Abstract:

In the late 1970s 3D printing started to become established as a manufacturing technology. Thirty years on the cost of 3D printing machines is falling to the point where private individuals in the developed world may easily own them. They allow anyone to print complicated engineering parts entirely automatically from design files that it is straightforward to share over the Internet. However, although the widespread use of 3D printers may well have both economic and environmental advantages over conventional methods of manufacturing and distributing goods, there may be concerns that such use could be constrained by the operation of intellectual property (IP) law. This paper examines existing IP legislation and case law in the contexts of the possible wide take-up of this technology by both small firms and private individuals. It splits this examination into five areas: copyright, design protection, patents, trade marks, and passing off. Reassuringly, and perhaps surprisingly, it is concluded that - within the UK at least - private 3D printer owners making items for personal use and not for gain are exempt from the vast majority of IP constraints, and that commercial users, though more restricted, are less so than might be imagined.

**A New Open Source 3D-Printable Mobile Robotic Platform for Education**


Abstract:

In this paper we present the Miniskybot, our new mobile robot aimed for educational purposes, and the underlying philosophy. It has three new important features: 3D-printable on low cost reprap-like machines, fully open source (including mechanics and electronics), and designed exclusively with open source tools. The presented robotic platform allows the students not only to learn robot programming, but also to modify easily the chassis and create new custom parts. Being open source the robot can be freely modified, copied, and shared across the Internet. In addition, it is extremely cheap, being the cost almost exclusively determined by the cost of the servos, electronics and sensors.

**IT WILL BE AWESOME IF THEY DON'T SCREW IT UP**

Weinberg, M. (2010). IT WILL BE AWESOME IF THEY DON'T SCREW IT UP.

Abstract:

The next great technological disruption is brewing just out of sight. In small workshops, and faceless office parks, and garages, and basements, revolutionaries are tinkering with the machines that can turn digital bits into physical atoms. The machines can download plans for a wrench from the Internet and print out a real, working wrench. Users design their own
jewelry, gears, brackets, and toys with a computer program, and use their machines to create real jewelry, gears, brackets, and toys.

**Changing How We Make and Deliver Smart Devices: When Can I Print Out My New Phone?**


Abstract:

The research vision of printing physical devices has been around for a decade, and in research prototypes, this vision is being realized. With fabrication laboratories (fab labs) emerging around the world and with more powerful modular computing platforms becoming available, the possibility of creating innovative smart devices and ubicomp products is becoming reality.

**3D Printer Toolchain**


Abstract:

We are still a long way from having our personal 3D printers work just like our microwaves, yet there has been a lot of progress made by a group of intrepid developers to not only give you options for how you want to use your 3D printer but to make it more reliable and easier to use. How we interact with our 3D printer is determined by the printer's toolchain: the electronics, firmware, control software, and slicing software that take a 3D model to a 3D object. If you bought your 3D printer as a complete kit or preassembled, then you probably have a set toolchain provided by the kit manufacturer. On the other hand, you might be piecing your 3D printer together from a variety of sources and are choosing parts of the toolchain that best fit your needs. Either way, this chapter is here to help you understand how these different parts of the toolchain work together. This chapter also introduces the idea of the 3D printer workflow as a way to use our printer's toolchain to make 3D prints. You might later decide to upgrade parts of your toolchain, so this chapter will help give you a place to start. For example, we might want to upgrade our three-year-old MakerBot Cupcake with new electronics running new firmware with advanced features originally designed for a RepRap. We might also want to upgrade our slicer program to make repairing models for printing a little easier. All of this would give us a significant upgrade in an older printer's print quality and performance, breathing new life into it.
VIRTUAL FACTORY FOR CUSTOMIZED OPEN PRODUCTION

Abstract:
This paper regards a holistic customer integration into value-creating with a focus on the development of manufacturing equipment. Therefore the paradigm of Open Production will be introduced and the practicability of openness will be evidenced by practical examples.

The Cambrian Explosion of Popular 3D Printing

Abstract:
The unexpected appearance of 3D printing has caught many technology analysts by surprise. In this paper we aim to provide a social context to the feedback loops that have generated this rapid evolution of technologies and skills involved in 3D printing, as well as online communities related to 3D printing and the impact of this evolution on media an popular imaginary... and our near future.

Three Dimensional Printing: An Introduction for Information Professional

Abstract:
Advanced by some as the next great emerging technology to enjoy overwhelming market penetration, three dimensional (3D) printing could have significant information implications, notwithstanding limited coverage in the information science literature. This review of complementary material from other sources provides the introductory definitions, technical descriptions and indications of future developments relevant to information professionals.
On the viability of the open-source development model for the design of physical objects


Abstract:

While open source software development has been studied extensively, relatively little is known about the viability of the same development model for a physical object’s design. This thesis addresses this deficit by exploring the extent to which this model is viable for the development of physical objects. It starts with a review of the relevant literature on open source and user innovation communities followed by a case study and survey of the RepRap community. This community develops a digital fabrication system that can 3D print a large share of its own parts. This allows for a decentralized community to independently produce physical parts based on digital designs that are shared via the internet. Apart from improving the device, dedicated infrastructure was developed by user innovators. The survey reveals substantial adoption and development of 3D printer technology, comparable to the larger vendors in the industry. RepRap community members are spending between 145 and 182 full-time equivalents and have spent between 382,000 and 478,000 dollars on innovation alone. At the RepRap project’s 6-month doubling interval, it is entirely feasible that its adoption and disruptive levels of innovation will exceed that of the incumbent industry. Within the community there is a higher incidence in modifications of hardware than in software, and, surprisingly, hardware modifications are expected to be relatively easier for others to replicate. The level of collaboration is also higher for hardware than for software. Through Thingiverse, a web-based sharing platform originating from the RepRap project, 1,486 designs of physical objects in the last 6 months. Also, more than 10,000 objects were independently manufactured by its members' machines. While already substantial, this level activity exhibits similar exponential growth characteristics. Many RepRap community members possess a fabrication capability that the average person does not have access to. While this does limit the present-day generality of the case study findings, there are many reasons to expect a high likelihood of personal access to digital fabrication in the near future. The rapid development and adoption of increasingly affordable, yet more powerful and valuable fabrication technologies and the anti-rival logic of open design allow user-dominant collaborative development to have significant implications for the provisioning of goods in society. Finally, I provide a discussion of the implications and make suggestions for further research.