Objectify: Better Living Through Anticipatory, Just-for-you 3D Printing!

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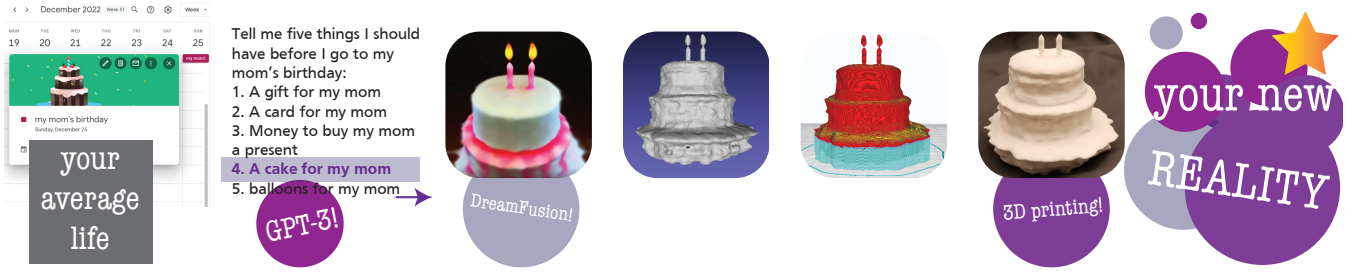

***Fig. 1:* Objectify's pipeline takes in a user's calendar data, uses a series of AI models to develop a bespoke 3D object based on it (generating text with OpenAI's GPT-3 [4]), then 3D models with Google's Stable Dreamfusion [14]), and either prints it right away or returns a ready-to-print version of the object to the user, with a timestamp indicating when to begin the print by.**

ABSTRACT

The ubiquity of 3D printers reveals a problem: people do not know what to use them for. If they do have an idea, they struggle to realize it, despite decades of research into design tools. However, consumption patterns suggest people still desire new objects, and advanced AI and digital fabrication point together toward an easy, post-scarcity future. This satirical advertorial presents Objectify, a program that harvests users' data to create bespoke objects they could want, just in time. Pushing 'cutting edge' AI's promises to their logical conclusion, our implemented pipeline uses AI-based content generation (GPT-3 [4] and Dreamfusion [14]) to ideate, generate 3D models, and print just-in-time objects. Objectify is 'pataphysical software [16]; created objects were non-functional monolothic pieces of blob-like single-color plastic. We discuss implications of the post-scarcity just-for-you vision of technological progress in AI and digital fabrication.

CCS CONCEPTS

• **Human-centered computing** → **Interactive systems and tools**; **Ubiquitous and mobile computing systems and tools**.

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KEYWORDS

3D printing, machine learning, design tools, technological charisma, 'pataphysical software

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1 INTRODUCTION

It feels today as if we are on the precipice of a new kind of future, where if you just articulate your grand vision into text it can become an eye-popping visual image you can use to support your story, pitch, or artistic expression. OpenAI, one of the pioneers of this space of visuals from text, invites users to help them "shape the future."[1] Yet right now, all your dreams and ideas stop at the edge of the screen, remaining ephemeral digital manifestations. Transforming the vision into something that you can touch, grasp, or use has remained an insurmountable challenge. Are we really only shaping a future of pixels? "You can't *shape* the future unless you 3D print it" says Dr. Valkyrie Savage, a digital fabrication expert at the University of Copenhagen. Indeed, this is the challenge Objectify takes on.

Remember last time when you were running out the door to go to a friend's birthday and realized you had forgotten to buy a present? You pick your keys up off the table and notice that your 3D printer has been busy, printing a birthday cake for your friend: it is now placing the finishing touches on the frosting. You didn't

[1] In their brand video at https://www.youtube.com/watch?v=AyOnug-3OKM

Fig. 2: **Our busy lives, planned ahead. (photograph courtesy of Bich Tran)**

forget about the gift after all! Since the party was in your calendar, Objectify had your back.

Using cutting-edge AI technology, Objectify organizes disparate information sources, such as health data from your wearables, events in your calendar, location data, your online communications with other people, and your shopping preferences to build a complete picture of you. Based on this, it creates a set of ideas for items that will be necessary for whatever you plan to do next, selects one and transforms its textual description into a brand-new just-for-you 3D model, then prepares that model for printing on a 3D printer, resulting in just-in-time delivery of the ideal object. Objectify is not merely a thinking technology, but a *thoughtful* one. It invites users to live their best life by doing everything as normal, like putting events in your calendar, talking to your friends, or shopping online; and allowing Objectify to take care of the rest. Pulling together the hottest technologies out there—OpenAI's GPT-3, Google's Dreamfusion, and 3D printing—Objectify will ensure that you always give perfect birthday gifts, enjoy a life with objects customised to your every wish and need, and never forget important documents again.

1.1 Why do my things matter?

Bestselling author and tidying expert Marie Kondo examines her clients' lives through the lens of their stuff: "It's important to understand your ownership pattern because it is an expression of the values that guide your life. The question of what you want to own is actually the question of how you want to live your life." She describes this process in her book *The Life-Changing Magic of Tidying Up*, and further discusses how swapping out the items one owns can be a part of the journey towards living the life one wants to live. As it stands today, most of the objects people own are either mass-manufactured or hand-crafted, but a third path is possible: deeply personalized customization on a mass scale through digital fabrication machines, such as 3D printers.

Researchers from top universities have spent over a decade—since patents on technology for fused-filament-fabrication 3D printers expired—trying to understand user needs and hopes around these miraculous machines that can make anything. Given the devices' extraordinary flexibility, it would seem users should have no trouble making the things they wish for, yet few people have integrated these devices into their lifestyles. This issue has many parts, including lack of affordable user-friendly printers, lack of commercially-available user-friendly design tools, and lack of knowledge around possibilities: these problems ultimately boil down to a common problem: "consumers lack the know-how and do not have or do not want to take the time to acquire it." A different facet of the issue is what is known as the analysis paralysis, where consumers struggle to choose between too many options.

The twin problems of "too little time" and "too many choices" have been solved previously by outsourcing tasks to other people, such as secretaries. During the Renaissance, secretaries were typically men, hired to aid important and wealthy figures with their day-to-day tasks as well as their correspondence. Today, secretaries still manage correspondence, and additionally take notes, control and manage calendars, order supplies, and more. As Marie Kondo teaches us, people live the life they wish to live through the footprints they make upon the world. For example, a person's calendar describes events that they plan (or wish to plan) to attend. Objectify stitches together the ideas that a person will plan their life as they want it to be, that they will need the backing of various systems and objects to support that life they want to live, and that they have little time or ability to select or design those items. There is no need to think ahead, no need to spend your energy shopping and making decisions. For the very first time there is no need to struggle to acquire complicated knowledge just so that you can use new technology. Now, you can live your life while Objectify ensures it is the *best life possible* by creating *just for you* objects without needing to be asked.

2 THE WORLD BEFORE OBJECTIFY

Of course, personalization is not a new idea. In fact, researchers, innovators, entrepreneurs have been chasing after the ideal of providing services and products perfectly customized to the consumer; the idea of "custom-made" continues to be a marker for both high quality and personalization. Yet getting products and services that are in fact a perfect fit remains a challenge, requiring the consumer to do the work of specifying their particular needs. The advent of powerful AI technologies promises to ease this burden, with targeted ads [3, 6], personalised pricing [7], and user-focused learning [2, 18] all using a fine-grained picture of an individual's needs to present them with their optimal reality.

While much of this effort so far has focused on intangible goods and services, research and innovation in digital fabrication and 3D printing has paved the way for true personalization and customization of physical objects.

2.1 Getting 3D Printers to Make What You Want

There are many traditional design tools for 3D printing out there. There are commercial software packages like Rhino or Autodesk's Fusion 360, and open-source tools like openSCAD. There are also many small and academic projects for creating 3D models for things you might want to print [8], printing prototypes [19], and making everyday objects smarter [15]. These are exciting! But whilst

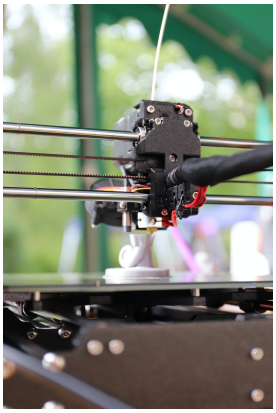

***Fig. 3:* 3D printers create a powerful opportunity for making new objects, but designing for them is a challenge! (photograph courtesy of Lucie Siegelsteinová)**

academics have the time to get a lot of background knowledge and the opportunity to think a lot about what they might want to create, that's not really an option for most regular people. Between working a job, looking after a family, visiting with friends, who has the time or interest in figuring out what they need or how to design it? If you can already take your heart-rate data from your heart-monitor and make chocolate treats out of that [9], why can't we just make everything else too? Chocolate is surely great, but it doesn't help when you suddenly need a screw-driver to fix your bike or realize you forgot to bring a pair of work-out pants for your yoga class. Objectify is here to help by creating a functional, beautiful 3D object when you need it, *just for you.*

3 OBJECTIFY: HOW IT WORKS

The first step is to show that this is really possible! A team of experts are hard at work on Objectify, but they are open in our work and invite the world to help. Right now, everything described here is available to the world as a series of python notebooks and shell scripts connecting various publicly-accessible research prototypes and open-source community tools. Are you a researcher or a tech enthusiast? Join us in creating this exciting future!

The amazing thing is how achievable this future already is. The overall pipeline can run on a single computer of sufficient power using a basic python script. This makes our product attainable to most and thus financially viable. In testing the minimum viable product, we used a combination of a Google CoLab notebook (which gets a user's data, creates a 3D model, and downloads it to the user's computer) with a cron job (which detects a newly-downloaded file and prepares and sends it for 3D printing). Anyone who wishes to Objectify themself can try these too, just visit our github repository: https://github.com/valkyriesavage/objectify. As Irina Shklovski, professor of computer science at the University of Copenhagen, notes: "the Objectify team has an extremely strong vision. It is very exciting that they are willing to open their vision and their technology to the world early on, so that everyone can participate and build a kind of future full of the objects they didn't even know they needed."

3.1 Getting to know the user

To be able to support people in their lives, Objectify needs to get to know them. To do this, Objectify collects data from Google Calendar (with the `ics` library) and in the future will also learn from many other data sources. The calendar gives Objectify ideas for which objects might be needed. This isn't as easy as it sounds [13], but Objectify is nothing if not creative. To make sure that the good ideas are the right ones, we make Objectify reflect on its choices:

```
Tell me five items I need to have before I go to
<event name>:
```

This is a start, but our calendars only say so much about us of course. So to craft a more personal understanding of the user right now we offer the opportunity to add some relevant personal text (this of course will be automated in the future):

```
My name is Valkyrie Savage. I am an assistant
professor at the University of Copenhagen. I average
9284 steps per day, and I am frequently at
Fælledparken in Copenhagen. I buy one bag of coffee
at Sneezing Fruits Cafe every 35.2 days. ...
Tell me five items I need to have before I go to
<event name>:
```

3.2 GPT-3: Object ideation

Using the prompt crafted in the previous step, Objectify calls up OpenAI's GPT-3[4] with their web-based API[2]. It sends the prompt to model `text-davinci-002` with `temperature=0.6`, OpenAI's suggested starting points. It then parses the returned completion and selects at random one of the five items suggested. If you need five items to go to a party, Objectify will select one to create.

3.3 Dreamfusion: Object model creation

Objectify is extremely cutting edge. Right now, it is built on the example notebook provided by the as-yet-unpublished Dreamfusion work, available on their project page [14]. It feeds the selected item prompt into the model and trains it with the default and recommended parameters; who has time for tuning? This takes approximately 3 hours (though we are working on getting the timing down to a much shorter wait-time to accommodate busy lives), and outputs a 3D mesh (OBJ file), a visible texture file (i.e., colours, as an MTL file) and a video flyaround of the object. Objectify uses the 3D mesh for further processing.

3.4 PrusaSlicer: Mesh repair and slicing

Dreamfusion is designed for creating 3D models with believable depth maps, but not for creating 3D printable solids. This means Objectify has to do a bit more work to make sure that generated objects are manifold solids (i.e., they do not have faces that are internal, floating, or zero thickness, or similar potentially strange issues) that can be used in 3D printing. Objectify also transforms the 3D model into a series of toolpaths that can be understood by the 3D printer. For both of these tasks, the beta system uses

[2]https://openai.com/blog/openai-api/

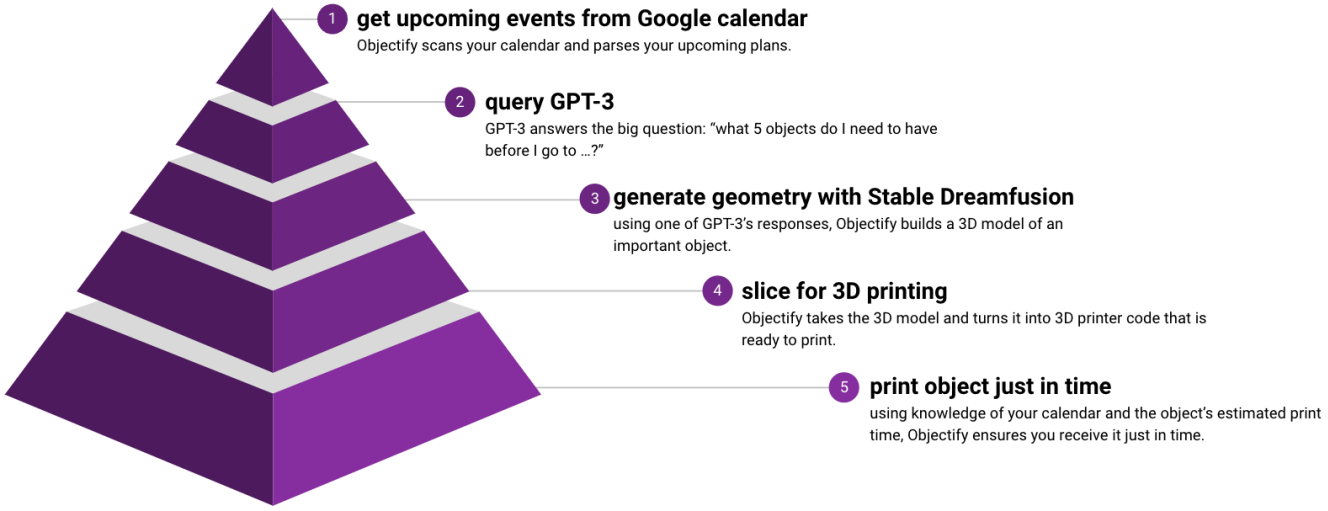

***Fig. 4:* The flow through Objectify. A user's information is processed by a sequence of advanced AI algorithms to create unique objects for them in the physical world just-in-time.**

PrusaSlicer[3]. In addition to the above, the system resizes the object to fit the printer's bed and print in a reasonable amount of time (max size: 100 mm x 100 mm x 100 mm), adds support material where necessary to accommodate overhangs, and configures print temperatures to work with PLA plastic.

Given the current time-demands to complete the process, today's version of Objectify is not instant, but instead can only respond to events scheduled far enough in advance. The system simply estimates the amount of time necessary to produce an object and schedules printing far enough ahead that the object will be finished just in time for the selected event or task.

3.5 Semi-manual fabrication of the final object

The test-version of Objectify does not yet print things automatically, but allows the user to make some decisions. The goal, of course, is to remove this step in the future. Once Objectify identifies what will need to be printed and how long that will take, the user gets an email containing a printer-friendly gcode file with no additional clues to what it might contain. After all, this is a surprise! They can then set this file to print on their printer (in our test, Valkyrie used a Creality Ender 3 Pro). This part is only semi-automatic, as current consumer-grade 3D printers are still notoriously difficult to work with and require fiddling and bed leveling between prints. In playing with the system, the co-authors configured it to send the requisite files to others for printing, thus preserving the feeling that objects "just appear." The future will see this process become fully automated, using printer control systems like Octoprint[4].

[3]https://github.com/prusa3d/PrusaSlicer
[4]https://octoprint.org/

4 LIVING WITH OBJECTIFY

So what does it feel like to live with Objectify? We got a sneak preview of the tool, allowing the first author to spend some quality time with this technology that is sure to redefine our future everyday lives. In an early trial, Valkyrie gave Objectify access to her calendar and used it to support her through participation in five events: a birthday, two work events, an international train trip, and sports practice. She brought whatever item Objectify produced to each event. These objects can be seen in Figure 7. While our goal was to use the system for at least a week, Valkyrie ultimately stopped sooner and we caught up with her to ask her how it went.

Valkyrie is a highly-ranked amateur player of jugger: a sport inspired by a 1989 movie which plays like a mix of fencing and rugby. It's not surprising, then, that the most frequent activity in Valkyrie's calendar is jugger practice, denoted as simply "sports." Objectify chose to offer her some support and printed a pair of shoes, or rather what constituted "athletic shoes" for the system.

Aside from that, Valkyrie, like many of us, regularly goes to work. She had multiple work meetings in her calendar, for which Objectify made her its perfected ideas of a "coffeemaker" and "workplace-appropriate clothing."

Valkyrie's mother's birthday is coming up, amid the stress of impending holidays and alt.CHI deadlines: Objectify freed her from anxiety when it found the party in her calendar and made a cake.

Finally, Valkyrie had some international travel, marked in her planner as "train trip Germany->Denmark." She tries to keep track of the documents required for such crossings, but with ever-shifting border practices it is difficult. Objectify printed her a shiny new passport, to present to the automated reader at the border.

4.1 What worked?

In our conversations about the experience, Valkyrie explained: "Objectify made me feel cared for, it truly became my secretary who

***Fig. 5:* In the workplace, we often need many items to achieve our goals. (photograph courtesty of Tima Miroshnichenko)**

***Fig. 6:* Celebrations are a time to be surrounded by the people and things we love. (photograph courtesy of Pavel Danilyuk)**

anticipated my every move and what I needed; I loved it! It was almost like getting gifts from a secret admirer. The incredible objects it made for me... I felt really *seen* by Objectify."

She further remarked on the fact that, while she has spent many years creating design tools for digital fabrication, it was nice for someone (or something) else to do the work for a change. "It doesn't get easier than this!" she quipped. The technology was working for *her*, rather than her working for *it*.

Objectify's vision takes the human error out of life. You always have what you need ready to go, at the right time—a birthday cake for your mom, for example. "To err is human, but to anticipate is Objectify," says Valkyrie with a laugh. In many ways, Valkyrie's experience aligned with the vision behind Objectify, but is it ready for prime time? Looking back at the objects produced, a few things may need to be addressed before a true revolution can happen.

4.2 Life in plastic: fantastic?

Objectify leverages local, just-in-time manufacturing as a way to obviate the need for warehouses and improve sustainability. "There was no need to wait or pay for expensive shipping or warehousing," says Valkyrie. "I picked each thing up fresh off of my printer."

Of course the immediate concern is sustainability of this process. After all, increasing the use of plastics can be problematic. While Valkyrie's 3D printers can only print in long-lasting single-color plastic, future sustainable 3D printing materials are just on the horizon. For example, we will soon be able to 3D print with fungus [12], biodegradable[5] and recycled[6] plastics, and wood fibres [11]. This means that in a very near future we can not only create but also re-create new customized devices as we need them, to reflect our own changes and growth.

While plastic is easy and can be extremely useful, it also has limitations beyond sustainability concerns. A birthday cake is somewhat less exciting, after all, if it is made out of plastic. In the future these limitations can be managed through different types of printers; it's just that Valkyrie didn't have access to them. "I just wish I had a food printer, the cake didn't taste very good as it was," she joked, plastic fragments obvious in her teeth.

All of the items that Objectify printed for Valkyrie were plastic, which made footwear and work-place clothing somewhat less usable than desired. However, even these issues will soon be addressed. Workplace appropriate clothing might be printable using a kinematics-type process[7], both established and new shoe manufacturers (such as Reebok[8] and Fused Footwear[9]) have experimented with printing shoes, and some 3D printers allow printing conductive materials alongside plastics (e.g., the Voxel8 printer, now owned by Kornit[10]). "I'm going to need a big grant to buy all these new printers!" Valkyrie cheerfully intoned. As Objectify gets ready for prime-time, we will be working on taking in the manufacturing technology and technique, to make sure that a pair of shoes are not printed in cake frosting and clothing is flexible in the right places. Piece of cake, as it were! We are almost there!

4.3 Fit to You?

Unfortunately, the shoes manufactured by Objectify did not fit on Valkyrie's feet as well as she might have hoped, and the clothing it produced did not get her through the workday. None of the objects were wearable or adjustable, but it's the thought that counts. This quirk of the prototype system could be easily fixed through additional data; commercial platforms such as Avametric[11] have for years promised body-fit clothing, and technological solutions to this challenge are in active development and ripe for integration into future versions of Objectify. Larger and finer-resolution 3D printers will continually expand the objects Objectify can make.

[5]https://b4plastics.com/products/compost3d/
[6]https://www.instructables.com/Recycle-Plastic-Into-3D-Printer-Filament-at-Home/
[7]https://n-e-r-v-o-u-s.com/projects/sets/kinematics-dress/
[8]https://www.adidas.com/us/4d-shoes
[9]https://fusedfootwear.com/
[10]https://ir.kornit.com/news-releases/news-release-details/kornit-digital-acquires-voxel8-expanding-additive-manufacturing
[11]https://www.ycombinator.com/companies/avametric

Fig. 7: **Objects generated and printed by Objectify for Valkyrie's events: athletic shoes for a sports practice, a coffee maker and workplace-appropriate clothing for two work meetings, a birthday cake for her mom's birthday, and a passport for an international train trip. Row A is the prompt event, row B is the list of 5 items needed (sourced from GPT-3) with the randomly-selected one bolded, row C is the 3D model generated by the open source version of Stable Dreamfusion, row D is the printed model (support material was not removed from objects with hovering parts).**

Valkyrie also mentioned how, in some ways, she found the objects less meaningful and could easily imagine throwing them away after a single use. This was in part because she had only to press "play" on the printer to get them. While this may seem wasteful, single use products are common and can often be effectively recycled. The ease with which Valkyrie was willing to let go of her objects could be a positive because letting go could create opportunities for generous donations to the less fortunate while opening up space in Valkyrie's life for new objects produced by Objectify.

Despite the relative unimportance of any one object, Valkyrie still felt that these objects reflected her *as a person*, since they were based on her data [17]. Of course, the calendar alone can be insufficient to truly understand a person, and sometimes the objects were less relatable than they could have been. She looks forward to a future version of Objectify with even more data and tools to improve how the system understands her likes, dislikes, and needs.

4.4 What can and should be printed?

Since Objectify is in its first stage of development, the AI was at times imperfect in its selection of relevant objects to print. On occasion, Objectify tried to print objects which typically remain in their digital form. The first of these was in response to an "online meeting" in Valkyrie's calendar: Objectify created a 3D model of "the internet" and tried to print it. Another time it created a 3D model of "calming music" for the event "relaxation time." Valkyrie stopped the printing process both times, as neither of these printed objects would be useful on their own: they represent parts of systems requiring other human and non-human things to function. Objectify also attempted to create personal objects for Valkyrie that might not need to be quite so personalized (e.g., a coffee machine at the office, which might normally be a common resource). These minor missteps were the result of insufficient personal data, which will be addressed by requesting that the future users provide access to all of the data they produce via all technical systems they encounter.

4.5 The world of AI is ineffable

The world of today features ever more machines and technologies interacting with each other in a network beyond our understanding. The passport object created by Objectify did not resemble a passport in a traditional sense, but who are we to judge the objects that computers wish to use to communicate with each other? "If I had put that [passport from Objectify] on the scanner and it had let me through," said Valkyrie, "I wouldn't have cared what it looked like."

Several of the objects fell into this category, where the model did not, perhaps, correspond to our human understanding of a given object. This is partially a limitation of the public-facing Stable

Dreamfusion library (they note on their github repository[12] that "current generation quality cannot match the results from the original paper, and many prompts still fail badly!"), which will doubtless advance. However, even our example objects with AI-driven qualities may become more useful in the future: as we are empowered beyond a plain physical reality by augmentation technologies like the HoloLens[13], more of our senses will be driven by computation and we will transcend traditional aesthetics.

5 WHERE DOES THIS LEAVE US? THE PROBLEM OF TECHNOLOGICAL CHARISMA

We can critically evaluate technologies, but at the end of the day we are charmed. It's hard to argue against the notion of progress.

While the advertorial above is a piece of satire, we acknowledge that no matter the critical turn, we—HCI as a field—are complicit in the capacity to overlook the problems as we are enchanted by Dall-E images (so easy, no longer need to think about creating images for your next lecture), GPT-3 text production (I wonder if my students will figure it out and how I will catch them with it), or DreamFusion's promise of being able to skip all the steps and make 3D models straight from a vague idea [1, 5]. There is a question of the goals of automation, though, and what does such speed eventually produce? We are in the world where we have arrived by "moving fast and breaking things," and we continue in that vein. The effort of making ideas real, however—how much is it worth? The environmental impact of Dall-E to produce cool images for your lecture—how much is that worth? How does our fascination with these technologies change when their outputs are no longer ephemeral to us, and when (part of) their environmental footprint is plastic filling our spaces with physical things we neither want nor can use? OpenAI, Google and other companies that are building large language models; and text-to-print, –to-image, or –to-model software; and other such wonders, claim to be revolutionizing the world. There is a pretty surface to all things GPT but in the end the reality of what these things can actually do is far less than advertised and often full of horrible mistakes, predictable biases, and reproduction of the status quo. How do we account for the excitement and charm masking the fact that most of this stuff is just ridiculous software solving imaginary problems [16], but some of it has very good PR departments?

The reflective process of engaging with objects and prototypes during their design [10]—iterating on them and considering them and the role they might play in your life or someone else's—can sometimes put the brakes on *having* and maybe forces us to recognize our thoughts and wishes as moving perhaps faster than our consumption instinct needs to move. A future in which everything is fast and easy may not be a future in which everything is good and useful. We look forward to CHI's continual self-examination while we go on making technology for its own sake and then explaining how it is going to change the world.

"We all live in a material world," quoted Valkyrie in closing, "and I am a material girl."

[12]https://github.com/ashawkey/stable-dreamfusion, retrieved 15 Dec 2022
[13]https://www.microsoft.com/en-us/hololens

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