Filling time, filling space: experiments with Interactive 3D Printing

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ABSTRACT

This paper documents the creative process of the author, a practitioner of computational art and design and an academic, during the development of their thesis on Interactive 3D Printing (I3DP). I3DP focuses on what it might look and feel like to be working as human practitioner in the new territories of the computationally-augmented creative arts, if these future artists and designers could truly work with 3D printing in a more programmatic, interactive way. The research process included the development of LivePrinter, an I3DP prototype, user studies, and associated creative outputs. These outputs form a record of experiments in computational ways of filling physical space (sculpturally), and filling time (musically).

Authors Keywords

3D Printing; I3DP; livecoding; computational art; fill patterns; interactive programming

CSS Concepts

• Human-centered computing~Human computer interaction (HCI)~Empirical studies in HCI

• Hardware~Communication hardware, interfaces and storage~Printers

• Applied computing~Arts and humanities

INTRODUCTION

This document collects experiments with an Interactive 3D Printing (I3DP) and Livecoding system called LivePrinter by the main researcher. These particular experiments were examples of self-reflective practice, combining visual aesthetics, physical structures, musical concepts, and live performances. Taken together, the images from these experiments illustrate the "theory nexus" [1] implicit in the researcher's "research through design" (RTD) approach: the different values embodied in the LivePrinter system and its outputs; the interactivity of the system; its social context of use; and finally the aesthetic possibilities afforded by using it.

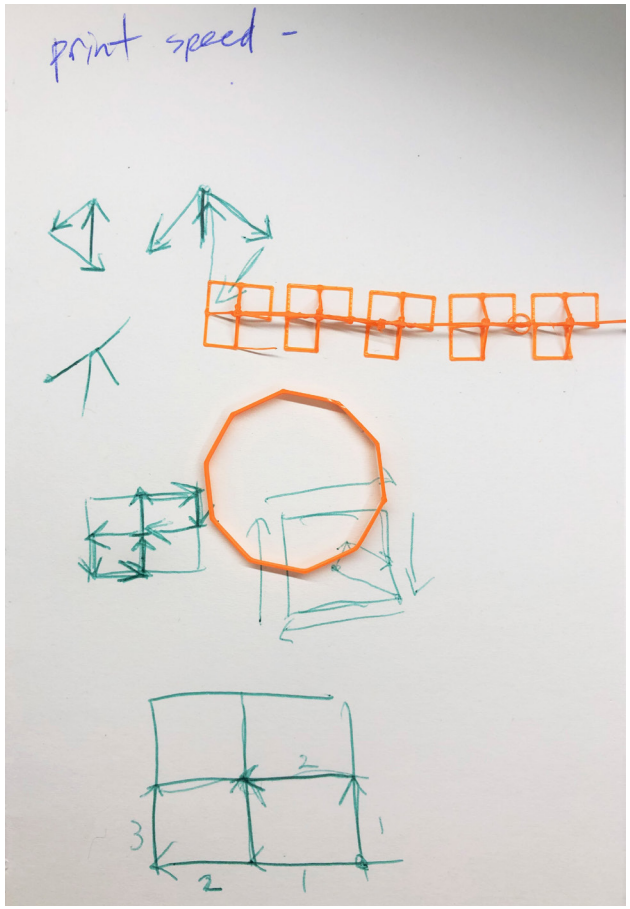
I3DP AND LIVECODING

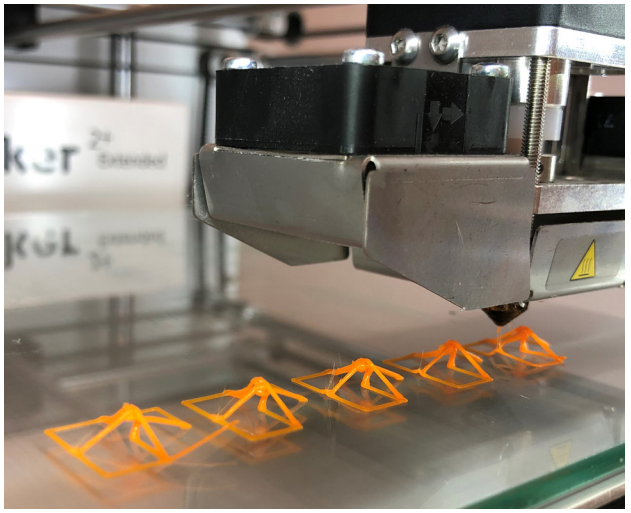
I3DP refers to the general technique of using interactive programming to control 3D printers, whereas Livecoding is a specific artistic practice in live performance settings that often employs the technique of interactive programming, or realtime software development. Livecoding often takes the form of musical performance, but can also take the form of directing the physical movements of people and machines, such as robots and 3D printers.

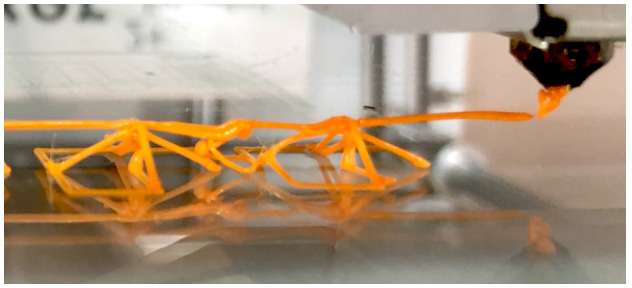
Designing systems that use code to computationally control machines in a live setting presents some unique HCI challenges. For I3DP, one of the biggest challenges is in designing notational systems for improvising new forms out of extruded lines of plastic, without cognitively overwhelming the user and without accidentally destroying those forms in the process. Other experiments explored some techniques for fast-prototyping sparse 3D forms, such as by using self-supporting triangles and sparse tetrahedrals.

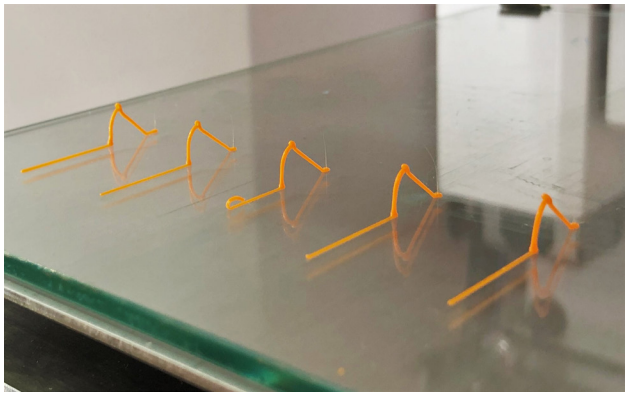
Reflecting on the experience of developing the supporting software and planning and performing experiments in this study led to new insights about computational techniques for interactive 3D printing and livecoding that point towards more efficient, sustainable processes that take less time and energy than current ones. It also led to possibilities for improving the shared aesthetic experience between performer and audience of long, interactive digital manufacturing workflows.

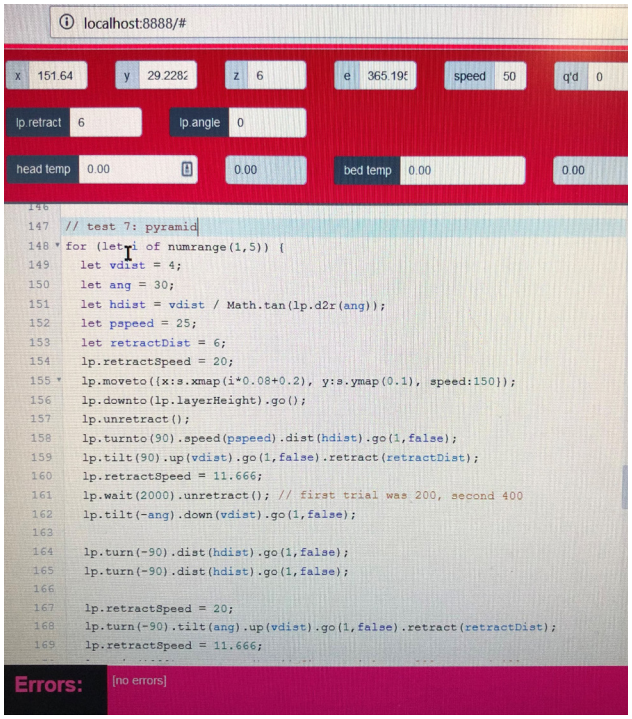
Finally, it produced artefacts which are aesthetically interesting in their own right, from 3D printed, 2D vector drawings to fully-3D tetrahedral structures. Some of these can be explicitly thought of as works of art, others are "happy accidents" that can be contextualised as art on reflection, and the rest can be considered to be byproducts of the experimental process.

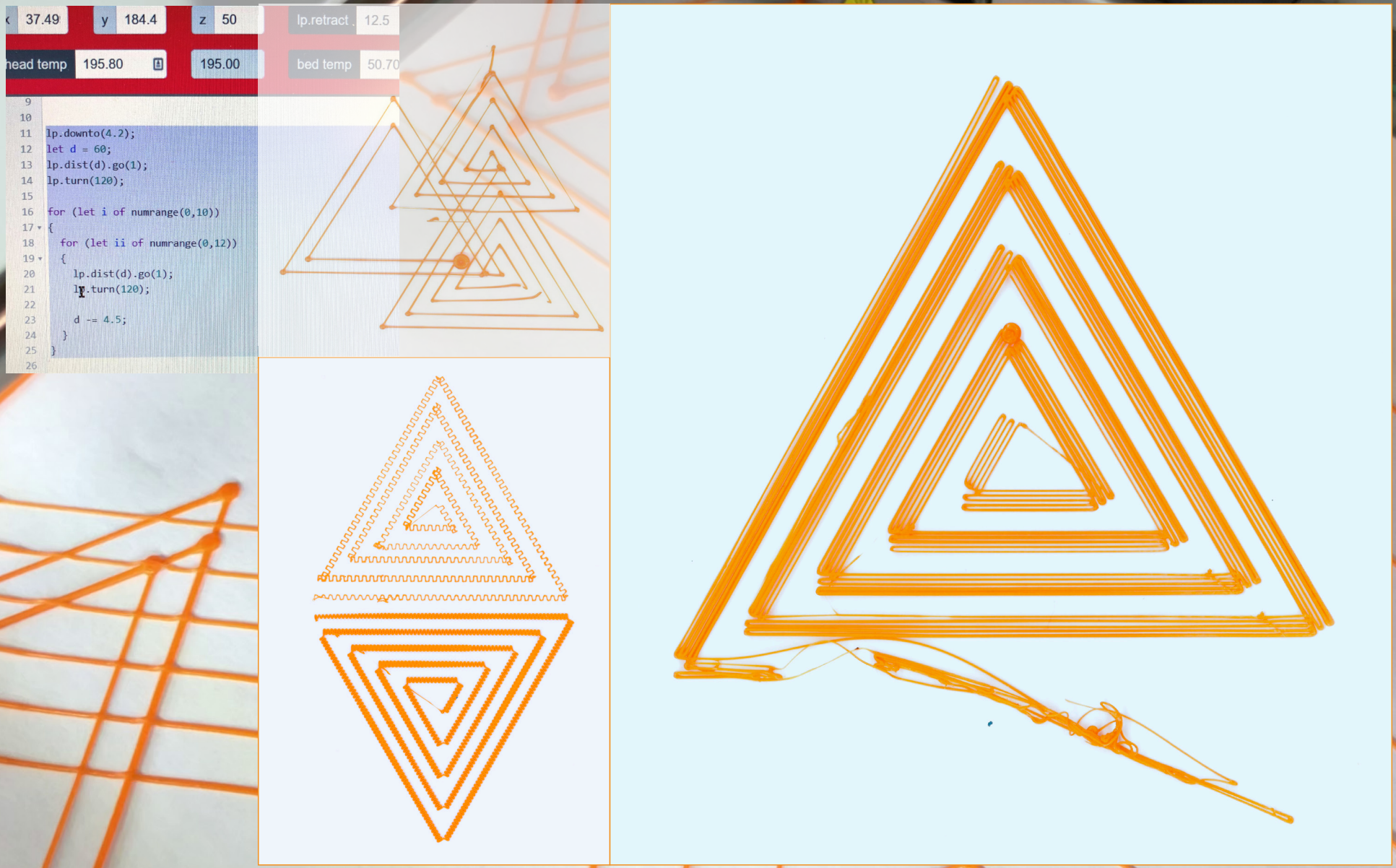

print speed -







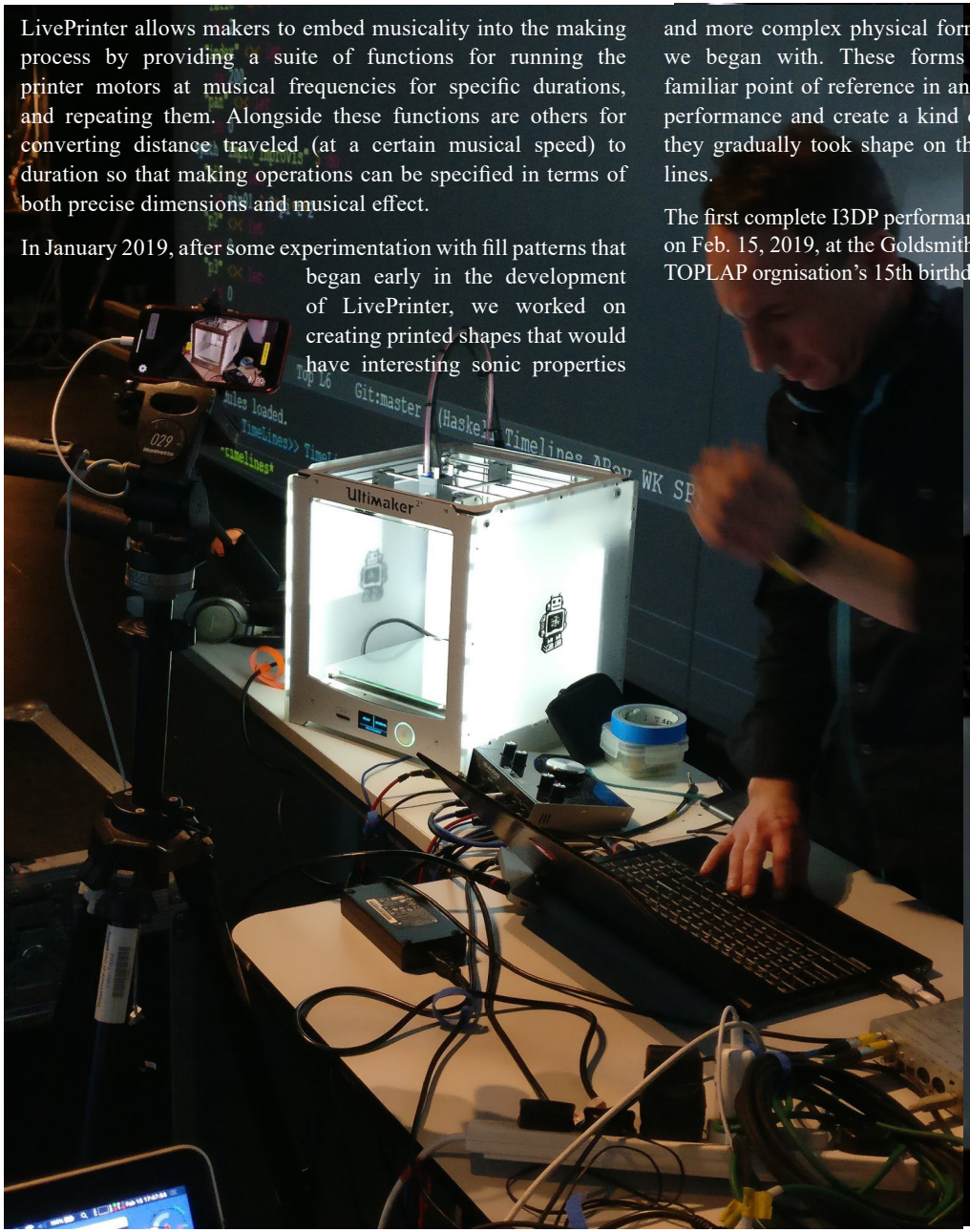

localhost:8888/#
x 151.64
y 29.2282
z 6
e 365.195
speed 50
q'd 0
lp.retract 6
lp.angle 0
head temp 0.00
0.00
bed temp 0.00
0.00
// test 7: pyramid
for (let i of numrange(1,5)) {
let vdist = 4;
let ang = 30;
let hdist = vdist / Math.tan(lp.d2r(ang));
let pspeed = 25;
let retractDist = 6;
lp.retractSpeed = 20;
lp.moveto({x:s.xmap(i*0.08+0.2), y:s.ymap(0.1), speed:150});
lp.downto(lp.layerHeight).go();
lp.unretract();
lp.turnto(90).speed(pspeed).dist(hdist).go(1,false);
lp.tilt(90).up(vdist).go(1,false).retract(retractDist);
lp.retractSpeed = 11.666;
lp.wait(2000).unretract(); // first trial was 200, second 400
lp.tilt(-ang).down(vdist).go(1,false);
lp.turn(-90).dist(hdist).go(1,false);
lp.turn(-90).dist(hdist).go(1,false);
lp.retractSpeed = 20;
lp.turn(-90).tilt(ang).up(vdist).go(1,false).retract(retractDist);
lp.retractSpeed = 11.666;
Errors:
[no errors]

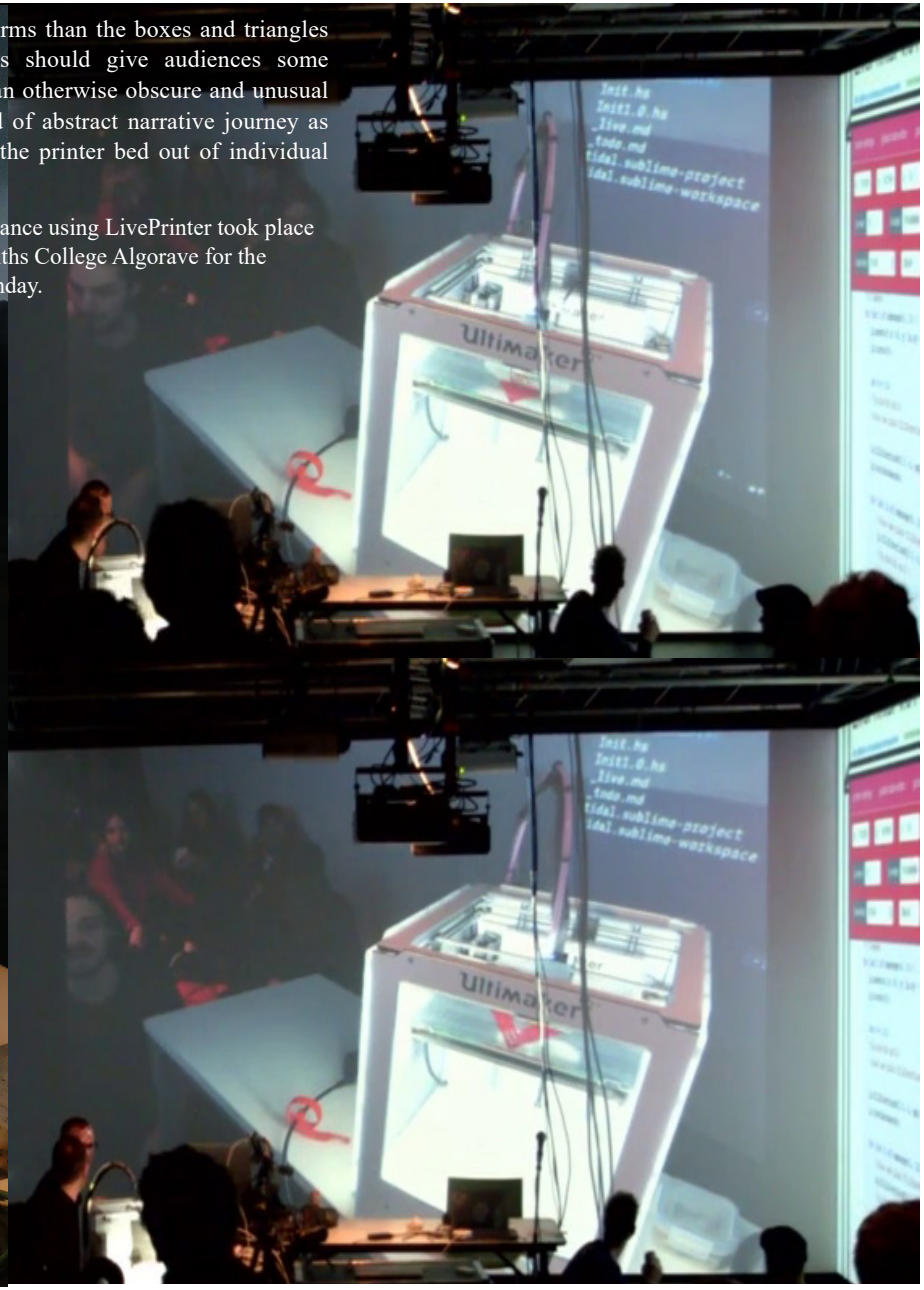

x 37.49
y 184.4
z 50
lp.retract 12.5
head temp 195.80
195.00
bed temp 50.70
lp.downto(4.2);
let d = 60;
lp.dist(d).go(1);
lp.turn(120);
for (let i of numrange(0,10))
{
for (let ii of numrange(0,12))
{
lp.dist(d).go(1);
lp.turn(120);
d -= 4.5;
}
}

LivePrinter allows makers to embed musicality into the making process by providing a suite of functions for running the printer motors at musical frequencies for specific durations, and repeating them. Alongside these functions are others for converting distance traveled (at a certain musical speed) to duration so that making operations can be specified in terms of both precise dimensions and musical effect.

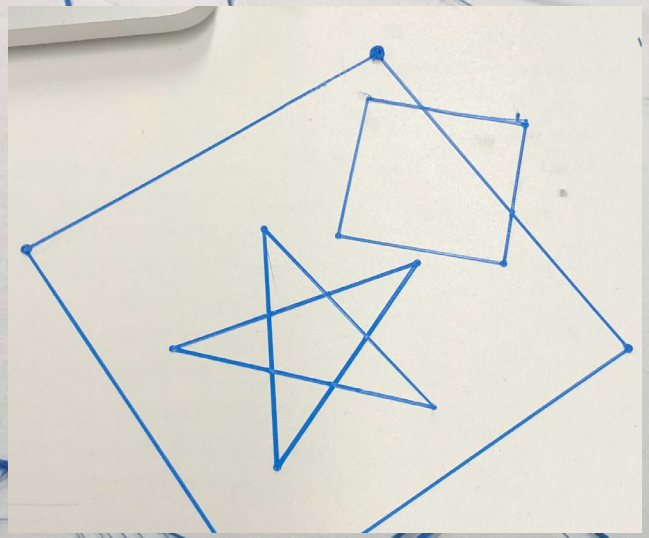
In January 2019, after some experimentation with fill patterns that began early in the development of LivePrinter, we worked on creating printed shapes that would have interesting sonic properties and more complex physical forms than the boxes and triangles we began with. These forms should give audiences some familiar point of reference in an otherwise obscure and unusual performance and create a kind of abstract narrative journey as they gradually took shape on the printer bed out of individual lines.

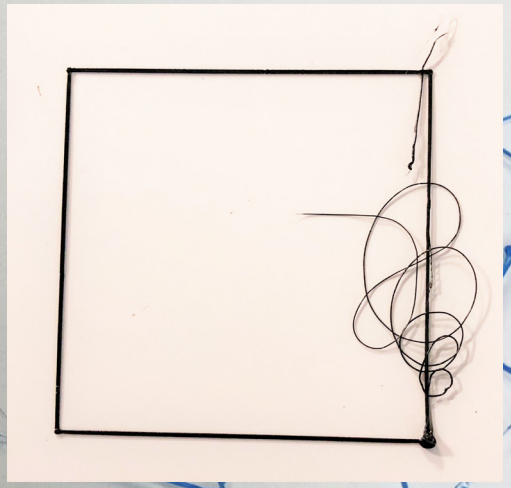
The first complete I3DP performance using LivePrinter took place on Feb. 15, 2019, at the Goldsmiths College Algorave for the TOPLAP orgnisation's 15th birthday.

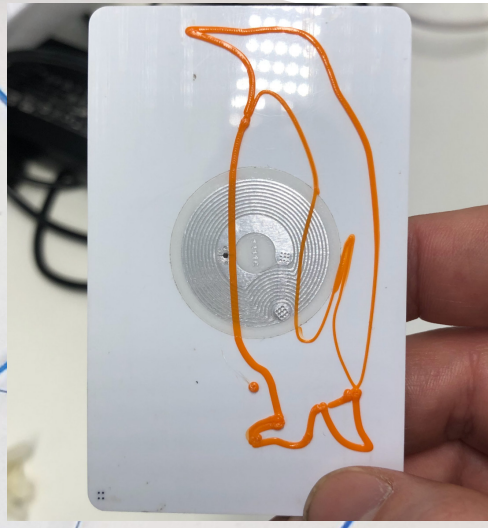


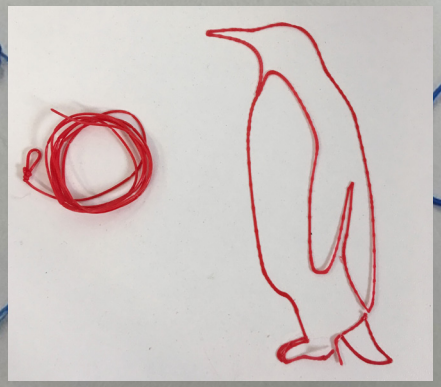


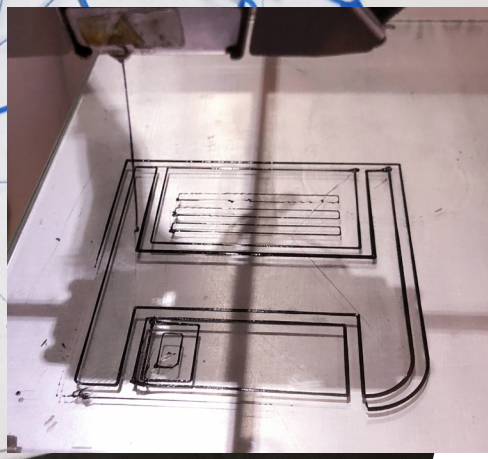
Partially as a test of the capabilities of the system, and as experiments in the aesthetics of 3D printing forms on paper and other materials, the researchers created drawings that could be rendered into LivePrinter code and manipulated in realtime programming sessions. They were useful in user workshops, alongside more “freestyle” drawing. Users and researchers printed on a variety of materials such as paper, acrylic, and even access cards.

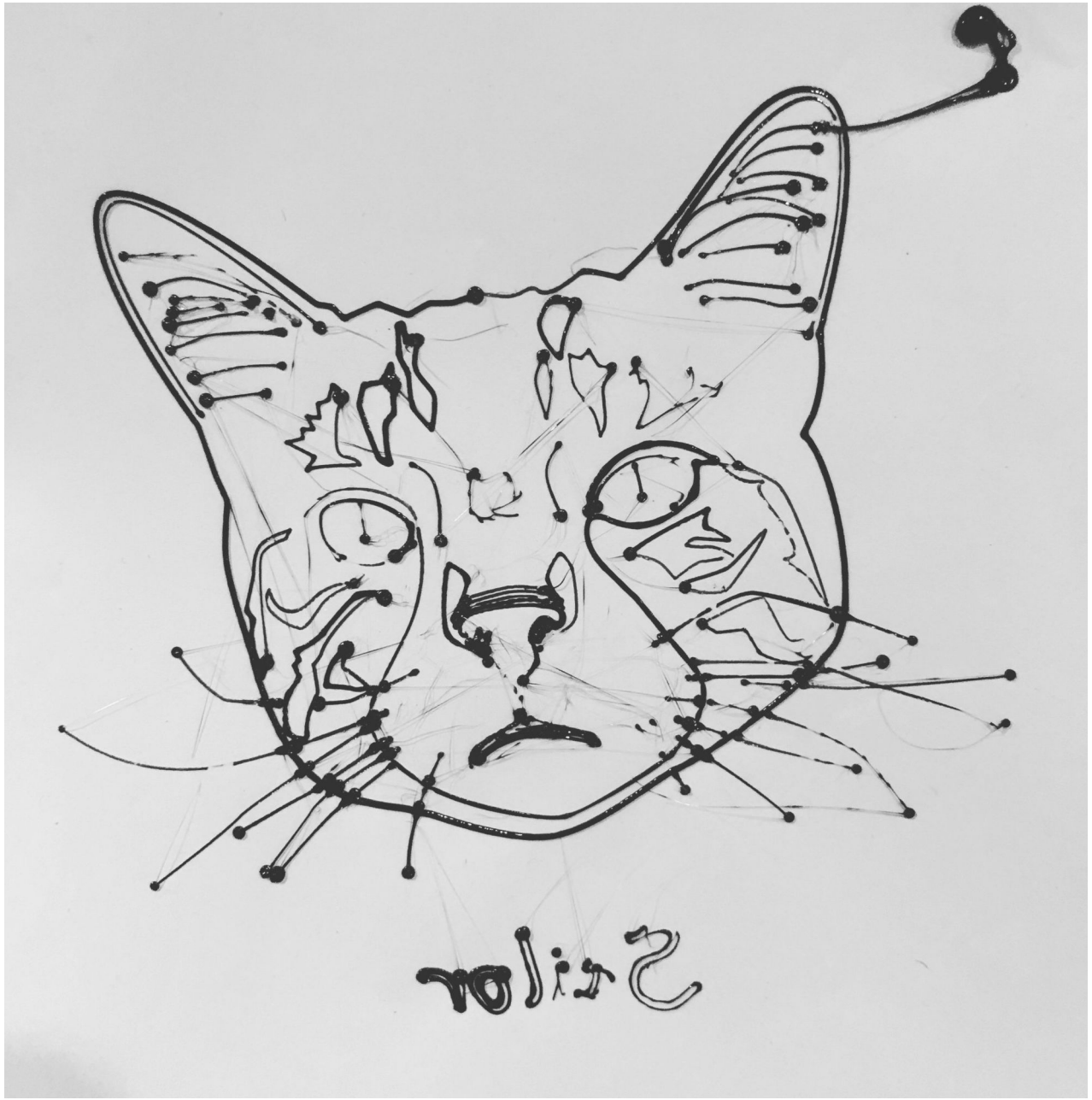












ACKNOWLEDGMENTS

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REFERENCES

[1] Collins R. 1994. Why the social sciences won't become High-consensus, rapid-discovery science. Sociological Forum 9(2) 155 - 177.