Fabricating Algorithmic Art

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Introduction

> 'We build our computers the way we build our cities – over time, without a plan, on top of ruins.'
> Ellen Ullman (1998)[1]

The above quote refers to the historical layers that make up our computer operating systems, where newly developed user interfaces are successively placed on top of the old ones, creating a kind of palimpsest. Behind the graphical user interface we find a text-based one, then a programming language, then a low-level assembly language, then machine and microcode, until we eventually meet with physical electronic circuits. The conventional timeline for computing technology as a whole begins earlier still, with the discovery of the electronic transistor a century ago. Each of these layers has had its heyday as the dominant user interface of its time, and indeed each has been used to make algorithmic systems for,

1 www.salon.com/1998/05/12/feature_321

or indeed as, art. There is much artwork to be recognised throughout this period, but if we keep digging, there are many more ruins to be found. Through research during our European Research Council project PENELOPE,[2] we find that algorithms have been present in everyday life for millennia. In the following we will explore some examples that support this claim, with a focus on our recent work while resident at the Textiles Zentrum Haslach in Austria.

Algorithmic dance culture

An algorithm is defined as a procedure or set of rules, to be followed without ingenuity, in order to create a reproducible result. Electronic computers follow algorithms, but so do humans. The traditional maypole dance is one common example in parts of Europe, whereby each dancer follows a set procedure to move around a central pole, weaving their ribbon inwards and outwards, and perhaps backwards and forwards, to create a braid on the pole. Once complete, the dancers must perfectly follow the rules backwards in order to unbraid the ribbons ready for the next dance. This dance takes some skill and training on the part of the dancers to complete a braid without

2 PENELOPE: A Study of Weaving as Technical Mode of Existence is an ERC Consolidator Grant Project funded by the European Research Council (ERC) under the Horizon 2020 research and innovation programme of the European Union (Grant Agreement No 682711), conducted at the Research Institute for the History of Technology and Science at Deutsches Museum, Munich.

errors, but as it is an algorithmic dance, ingenuity is unwelcome. The correct braid is defined in advance by the rules that are followed.

Another algorithmic dance is the Pinnal Kolattam of Tamil Nadu, India. There is no pole, and the dance is done at harvest-time rather than springtime, but like the maypole dance, each dancer follows a procedure while holding a ribbon, in order to collectively braid, and unbraid. The dance, and therefore the resulting braid (Pinnal) is more intricate than the European maypole dance. In addition, each dancer holds a stick, struck together in pairs as dancers meet, creating musical rhythm from the dance. As with maypole dancing, the choreographic creation of such a dance requires great ingenuity, but the dancers themselves must not show ingenuity, otherwise the braid will contain an error, and unbraiding it will be difficult.

Textiles Zentrum Haslach

During our residency at Textiles Zentrum Haslach in Austria in early 2018, we researched the long history of textile machinery on view within this working museum. It is difficult to imagine a better place to ponder the historical depth of algorithmic art than at Haslach, with its wide range of looms and other devices for translating algorithmic patterns into cloth. Here we find the Jacquard device, famous among computer scientists for its card reader, which inspired the input mechanism for Charles Babbage's computing

machinery in the 19th century. However, next to the Jacquard device we find the earlier brose machine (German: *Bröselmaschine*) that was used in Upper Austria by handweavers to replace the drawboy when working at draw looms. The brose machine follows the same principle whereby material is fed into the machine, while ups and downs are controlled not by holes in cards, but by wooden blocks pasted onto linen. The Landesmuseum Linz owns some better-known brose machines that are said to have been invented around 1680.[3]

So famous is Babbage's device that it obscures not only precursors such as the brose machine, but perhaps even more importantly the far longer history of algorithms in the art of weaving; Babbage's analytical engine was designed approaching 150 years ago, and the brose machine over 330 years ago, but there is evidence that weaving has been done by humans since the Palaeolithic era, i.e. for 27,000 years. By definition, all weaving involves a step-by-step procedure, of discrete ups and downs, where the weft thread travels either over or under successive warp threads. In other words, weaving has been a digital, algorithmic art, for many thousands of years, since its very beginning. Indeed, Jacquard- and brose machines are not looms in themselves, but technologies to be

3 Adolf Adam, former professor of computer science at the Kepler University in Linz, has set that date according to the mention of a 'magic loom' by Johann Joachim Becher in the report of the Austrian Academy from 1680. Adam says that the loom with a brose machine was the first program-controlled production machine, equipped with an endless loop and able to weave patterns for up to 40 shafts (Adam 1985, 63).

added to an existing loom. Before their invention, algorithms were interpreted and carried out by people – however, they were algorithms nonetheless. From here, the history continues back, as a history of the algorithmic movement of bodies.

A pleasing link between the algorithmic movement of machines and the algorithmic movement of human bodies is found in the industrial braiding machinery also present in Textiles Zentrum Haslach. This includes the maypole braiding machine, which sends one circle of bobbins of different-coloured threads in one direction, and another circle in the other direction, the bobbins in the second circle moving over and under those of the first circle to create the braid. When being demonstrated at industrial speed, the bobbins are a blur, but can be gradually slowed down until a striking similarity to the human maypole dance suddenly becomes clear.

One of the aims of our PENELOPE project is to explore the place of ingenuity in textile procedures such as braiding and particularly weaving, when conducted by a human. With the maypole, an individual dancer must not show ingenuity, but a 'caller' may often shout out new instructions for all the dancers to switch to in synchrony. This live manipulation of algorithmic procedure is also possible by a weaver, who may change their plan, switching to a different pattern of movement in such a way that two woven structures are integrated without undesirable 'floating' threads. The weaver also shows ingenuity in the setting-up of the loom, which can be a long and complex procedure, setting the creative constraints of what may be produced. By definition we do not show ingenuity in following an algorithm, but we may nonetheless show ingenuity in creating an algorithm, or indeed changing the algorithm while it runs.

Live coding and Algorave

Returning to contemporary technology, we turn to the TC-1 loom, which is unusual in being both a hand loom, and computer controlled. A computer is used to control the up/down position of each warp thread for each weft thread via pneumatic heddles, but the weft is then passed and beaten into the warp by hand. While visiting Textile Zentrum Haslach, we wanted to explore how a loom could be controlled by TidalCycles, a system originally created for the algorithmic expression of music[4] (Magnusson and McLean, 2018). TidalCycles is designed for *live coding* music, where computer code is written and manipulated while it runs, often to make music for an audience. TidalCycles is a free/open source project used by thousands of people around the world, including at Algorave events[5], where people dance to music created by such algorithms (Collins and McLean, 2014).

Although intended for music, TidalCycles is

4 TidalCycles is a free/open source project originally created by the first author (McLean). See http://tidalcycles.org for more information on this system, including demonstration videos.

5 Algorave is short for 'algorithmic rave'; see http://algorave.com for details.

essentially a language for describing abstract patterns, which may be rendered as weaving patterns just as well as musical patterns, as long as they are constrained to form a grid of binary values. The following code is one example of such a pattern.

```
stack [superimpose id tabby,
       superimpose id $ superimpose id $
superimpose (rev . ( (3/12) <~) ) $ every 2
(rev . ( (2/12) <~)) $ superimpose (rev .
(0.25 <~)) $ superimpose ( (1/4) <~) $
"[<black white> <white black>]*3",
       tabby,
       superimpose id $ superimpose (rev .
(0.25 <~)) $ every 2 (rev) $ superimpose
(rev . (0.25 <~)) $ superimpose (iter 4) $
superimpose ( (1/4) <~) $ "[<black white>
<white black>]*3",
       tabby,
       iter 6 $ superimpose rev $ superimpose
( (1/6) <~) $ superimpose ( (1/12) <~) $
"[black black white white black white]*2",
       tabby,
       superimpose id $ superimpose (rev .
(0.25 <~)) $ every 2 (rev) $ superimpose
(rev . (0.25 <~)) $ superimpose (iter 4) $
superimpose ( (1/4) <~) $ "[<black white>
<white black>]*3",
       tabby,
       superimpose id $ superimpose id $
superimpose (rev . ( (3/12) <~)) $ every 2
(rev . ( (2/12) <~)) $ superimpose (rev .
(0.25 <~)) $ superimpose ((1/4) <~) $
"[<black white> <white black>]*3",
       superimpose id tabby
]
```


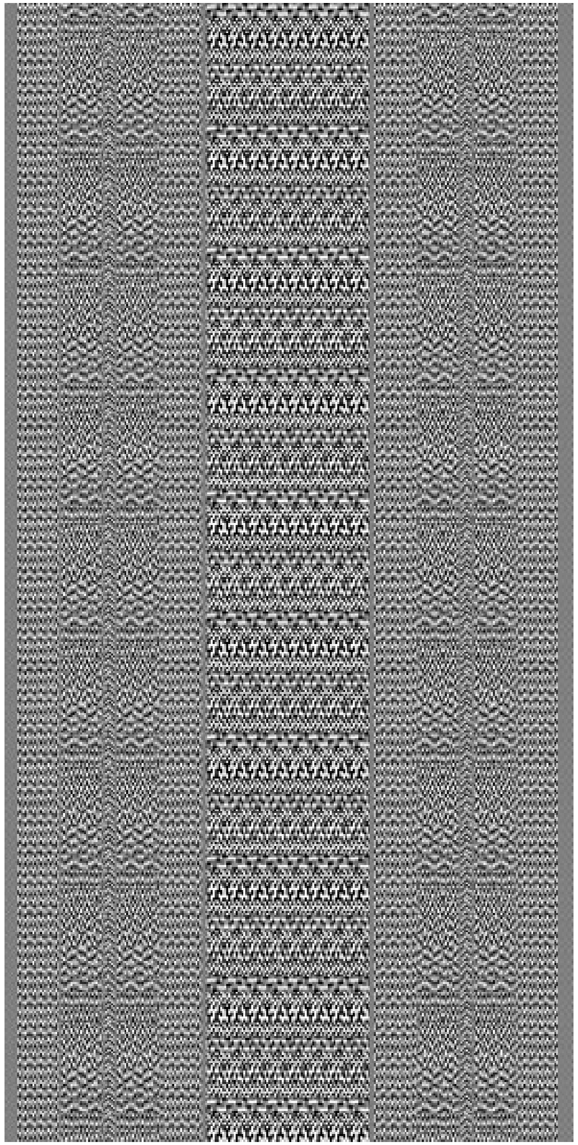

Fig. 1
A weave pattern created with the TidalCycles live coding software, shown with the warp running horizontally. The left and right thirds were produced using the code example on the facing page.

Fig. 2
The resulting fabric shown on the TC-1 loom
in Textiles Zentrum Haslach.

Fig. 1 shows the output from the code excerpt, while the resulting weave created on the TC-1 loom is shown in Fig. 2. In this case the warp threads were black, and the weft threads were white, and so the woven structure of ups and downs are clearly visible in the resulting image. In the future we plan to explore colour effect patterns which result when successive threads alternate between colours on both the warp and weft threads, creating interference patterns that are visually very different from the structure that gives rise to them.[6] We also wish to link the code more directly to the loom, so we may more easily change the algorithm while it is being woven, essentially live coding the loom.

Conclusion

In this article we have brought forward examples of algorithmic procedures within the dance of human movement. By connecting a computer language designed for creating dance music with a computer-controlled hand loom, we have created a patterned, woven fabric which expands these ideas further. Weaving is an ancient art form, and demonstrates that human culture has always included algorithmic procedures following discrete patterns. We argue that computer art should be thought of in these terms

6 See some colour and weave drafts on handweaving.net here: https://bit.ly/2I2ISUa. The examples stem from the draft book of Franz Donat (1907).

in order to break the usual frame of reference to post-industrial innovation – which too often needlessly constrains discussion around algorithmic art. The long and living history of machines as demonstrated at Haslach tells us an alternative story, of people (usually women), engaging in the mathematics of weaves in order to transform patterns as part of a thriving digital art embedded in our culture for millennia.

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Biographies

Alex McLean completed his PhD thesis Artist-Programmers and Programming Languages for the Arts at Goldsmiths in 2011, and he has since expanded research interests in the intersection of music, pattern and programming languages to include textile structures, now as post-doctoral researcher on the ERC PENELOPE project, exploring the structures of ancient weaves. Alex is also a performing musician, developing a live coding practice since the year 2000, performing regularly at major festivals and venues. He created the TidalCycles live coding language for this purpose, which is now an active free/open source project. Alex curates and organises strange events as part of his creative practice, co-founding the TOPLAP and Algorave movements, and co-founding the AlgoMech festival and international conferences on live coding and live interfaces. He also works as an independent artist, with recent residencies in the Open Data Institute and Playgrounds exhibition. Alex is based in Sheffield, where he is trustee of the Access Space charity working in arts, technology and education. He recently co-edited *The Oxford Handbook of Algorithmic Music* with Roger Dean.

Ellen Harlizius-Klück is Principal Investigator in the PENELOPE project. From September 2014 to March 2016, she worked together with Alex McLean and Dave Griffiths as international Co-Investigator in the Weaving Codes – Coding Weaves Project, funded by a Digital Transformations Amplification Award 2014 of the Arts and Humanities Research Council (UK). From April 2014 to October 2015, she investigated the philosophy of ancient textile production as post-doc in the Collaborative Project Ancient Textiles, conducted by the Centre for Textile Research, University of Copenhagen, and the Department of Ancient History, Leibniz University Hanover. In 2012 and 2013, she was awarded a Marie-Curie Senior Research Fellowship funded by the m4human programme of the Gerda Henkel Foundation (COFUND) at the Centre for Textile Research, University of Copenhagen. In 2006 she was Scholar-in-Residence at the Research Institute for the History of Technology and Science, Deutsches Museum, Munich. Ellen is educated as a mathematician and artist and holds a PhD in philosophy.

Relevant Projects

PENELOPE: A Study of Weaving as Technical Mode of Existence is an ERC Consolidator Grant Project funded by the European Research Council (ERC) under the Horizon 2020 research and innovation programme of the European Union (Grant Agreement No 682711), conducted at the Research Institute for the History of Technology and Science at Deutsches Museum, Munich. Ellen Harlizius-Klück is Principal Investigator in this project, pursuing weaving as the very first instance of digital art in history. The research team further includes Alex McLean (live coder and art programmer), Flavia Carraro (ethnologist and anthropologist), Giovanni Fanfani (classical philologist) and Dave Griffiths (director of FoAm).

Weaving Codes – Coding Weaves was a project funded by a Digital Transformations Amplification award from the Arts and Humanities Research Council running from September 2014 to March 2016. Alex McLean, as Principal Investigator, pursued the question of historical and theoretical points at which the practice of weaving and computer programming connect, including insights that could be gained when these activities are brought together, through live-shared experience. Together with Ellen Harlizius-Klück as international Co-Investigator and Dave Griffiths, he investigated patterns from the perspectives of weaving and music, and developed a computer language and code for describing the construction of weaves. Ancient looms in this context are seen as early digital art machines that prefigured concepts of dyadic arithmetic and logic.