

Manual NC Plotter

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1 Introduction

Even in today's world where we can touch information very intuitively with a gadget such as an iPhone, it is still interesting to know, actually, how bits are translated to physical matters and vice versa. Printers, for instance, print digital images on actual paper by moving its motors according to electrical signals. As to digital fabrication technologies, only 3D printers and laser cutters are often in limelight at the moment but this field's objective is how things can be digital, or how to translate bits into atoms and atoms into bits.

In this research, we developed a plotter (Figure 1) which is computer numerically controlled but you need to make it work manually and which works without electricity but with gears. We also developed an application software (Figure 2) which generates vector data of racks (straight gears) according to your arbitrary drawings. You laser-cut the racks and insert them into the plotter and rotate a handle of a gear, then the plotter draws your drawing on a paper. This machine helps us to understand easily how information is translated into bits (data of 0/1) and how bits are translated into real things, and what digital actually means. For instance, how an oblique line can be described by a set of 0 and 1 was a problem when we developed the application, and it probably also was a problem in the early period of computer graphics. This manual NC plotter may be able to make bits more tangible than an iPhone.

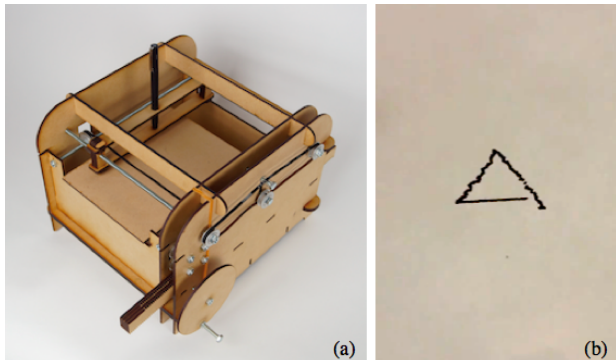


Figure 1: (a) The manual NC plotter (b) A plotted example

2 System

We developed an application which generates vector data of racks according to your drawings. (Figure 2) Racks, which are straight

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gears, moves in a horizontal direction by the rotation of a pinion (a circular gear) and vice versa. The rack which our application generates has parts with gear teeth (teeth parts) and parts without teeth (null parts), which represent 1 and 0, respectively. When a teeth part is inserted, the pinion rotates then the pen moves, while the pinion and the pen do not move when a null part is inserted. Our application generates 4 types of racks, which are X-axis plus direction, X-axis minus direction, Y-axis plus direction and Y-axis minus direction. After laser-cutting them, you need to stick them together. (Figure 3a) The insertion slot of the plotter has 4 pinions, each of which is engaged with each of 4 types of racks, then conveys a power to the pen to move in each direction. (Figure 3b)

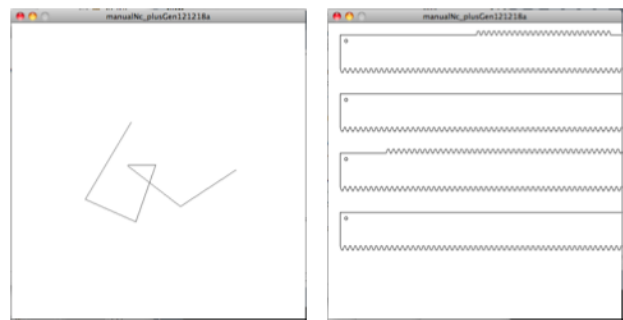


Figure 2: The application which generates vector data of racks. Press *s* after drawing then it generates racks (the right image).

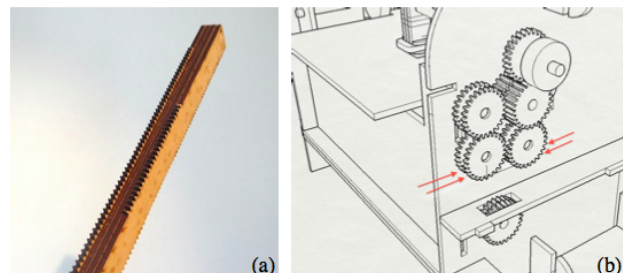


Figure 3: . (a) A laser-cut and stuck set of 4 types of racks (b) The insertion slot has 4 pinions to engage with the racks

3 Algorithm

We used the Bresenham line algorithm [Bresenham 1965] to approximate oblique lines. The head of the plotter can move only vertically and horizontally so oblique lines should be approximated with sets of short lines in the directions of X-axis and Y-axis. The Bresenham line algorithm was developed for digital plotting and now is commonly used for describing lines with pixels on a computer screen.

References

BRESENHAM, J. E. 1965. Algorithm for computer control of a digital plotter. *IBM Syst. J.* 4, 1 (Mar.), 25–30.