Using parallel kinematic robots for 3D printing

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3D printing could be a part of the next industrial revolution, hoping to change outsourcing trends to low wage countries. Two emerging branches of 3D printing are printing very large or very small objects, ranging from houses to biomaterial for printing human skin. In this summary of our master thesis at LTH we talk about how it is possible to use big industrial robots as a 3D printer to print large scale objects, and how we made a prototype printer head for this purpose.

As technology develops and 3D printers are becoming more and more affordable, this might lead to a change in consuming patterns. Instead of buying factory-made simple plastic details, in the future the customer could print it on demand on site. In 2014 NASA sent the first item, a ratchet wrench, via e-mail to the International Space Station to be printed in space [NASA, 2014].

Promising future application areas are aerospace, automotive and electronic industries [Zhang et al., 2014]. This makes 3D printing an interesting industry that is predicted to be worth $12.8 billion by 2018 [Woh, 2014].

What makes this technology very interesting to industry is the fact that it is able to create extremely complicated shapes that conventional subtractive manufacturing processes would not be able to replicate. For example 3D printing can be used to print moving parts such as cogwheels already assembled. Another aspect is that there is almost no waste of material, since it only uses the material that it needs to make the part, except for support material whereas in traditional subtractive manufacturing processes, such as milling, almost 95% of the raw material is often wasted [Excell and Nathan, 2010].

Currently the size of manufactured objects are both shrinking and growing. For the applications where the printed object is growing, industrial robots are an alternative for moving the printer head that is both flexible and cost effective. The robot studied in this article is a Gantry-Tau parallel robot. It consists of three parallel rails on which three carts can move independently. Each of these carts has a cluster of arms attached, and each cluster of arms is attached to the tool, in this case the printer head.

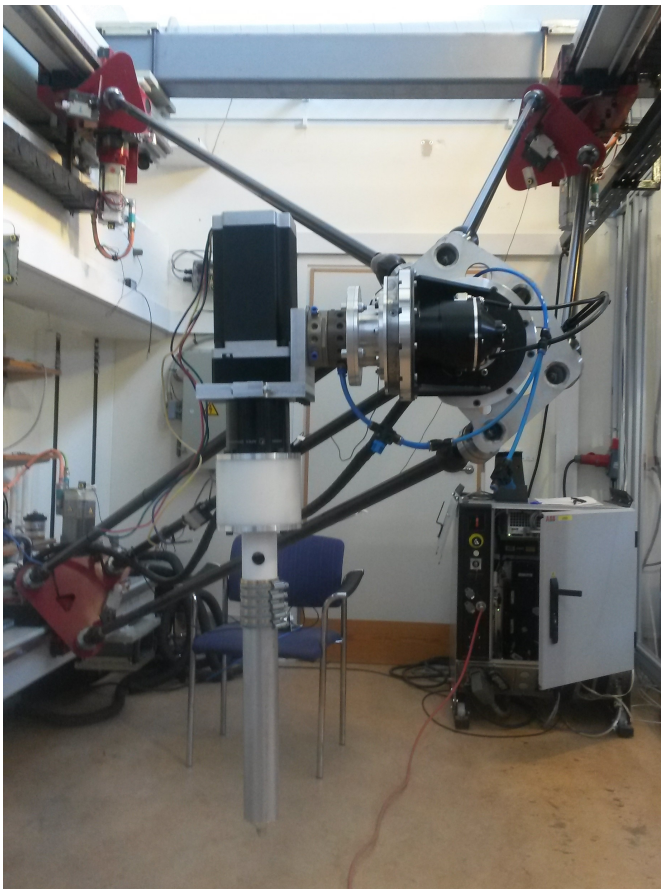

Fig. 1. The printer head prototype attached to the parallel kinematic robot at the Robotlab, LTH, Lund University

In our master thesis both the calibration of the robot and the design of a printer head for plastic have been made [Lilja and Sola Merino, 2015]. The motion of the robot is determined by its kinematic parameters e.g., lengths of the arms or parallelism of the rails. The calibration is needed to compensate for deviations in the nominal values of these parameters, due to manufacturing or mounting faults. Thus, the goal was to improve the accuracy of the robot by identifying more suitable kinematic parameters with the aid of a camera vision system. Promising results were obtained, reaching an accuracy of 0.4*mm*.

The printer head for plastic was designed following the working principle of an injection moulding machine. A screw driven by a motor pushes plastic pellets through a pipe while they are heated up until melted. Then the melted plastic is pushed through a nozzle to get an output thread of plastic. The objective of the printer head is to reach a high flow of plastic, since available printer heads in the market are meant for desktop printers, and not for printing big parts. In our design we basically scaled up an existing printer head to fit our needs. Figure 1 shows both the parallel robot and the plastic extruder attached to it.

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