Six-axis robot turns 3D printing into an art form

Ratingen, Germany, 26th July 2018

A project at the Centre for Fine Print Research (CFPR) based at the University of the West of England, (UWE) Bristol UK is looking at 3D printing from a totally different angle - where the emphasis is placed on meaningful expression, rather than the accurate reproduction of digital data. A flexible Mitsubishi Electric MELFA RV-Series articulated arm industrial robot is at the centre of the project.

Additive Manufacturing (3D printing) is increasingly being used in the manufacturing industry for prototyping, low volume manufacture and for making items with complex shapes which cannot easily be reproduced by other means. The main challenge is posed by complex geometry; when an object is to be fabricated, the shape must be broken down into a series of machine tool paths that will accumulate material by building up layers in a stable and reliable way.

For this reason, 3D printing is generally a very precisely controlled process, both in terms of the type of movement (steady acceleration and velocity) and the deposition of materials. In industrial applications, material is deposited or fused in small quantities. The machines are accordingly operated in a logical, numerical way, just as in CNC machining.

Conversely, the Centre for Fine Print Research (CFPR) project is looking at 3D printing from the viewpoint of the Arts, where the emphasis is

placed on meaningful expression. A good analogy to the project would be the potter’s wheel, where the artist works in direct contact with clay and with an intimate understanding of the constraints of working the material and the wheel in synergy.

Here, the artist is able to express something with the material, often pushing the material to its limits, for example by generating sweeping elegant forms, or revealing new material qualities, such as translucency. The CFPR has background expertise in ceramics, photo-cure resins and thermoplastics, all of which are being investigated with the new robotic platform. Previous work has evaluated the 3D printer as a tool to manipulate materials, or produce unusual surface textures, as opposed to simply using it as a machine that reproduces digital models at a fine resolution.

Using a printer in 'unusual ways' means moving beyond simply using CAD models and slicing algorithms, as these are too automated. By writing proprietary software, it is possible to develop printing methods from the point of view of how the material can be expressively played with.

In order to achieve this shifted perspective, the project is using a Mitsubishi Electric MELFA RV-7FLM robot arm to research technologies and techniques to sense and manipulate materials in a dynamic way, rather than deposit them in fixed, rigid or ‘machine-like’ ways. The robot is running printer paths defined by proprietary software and requires a high degree of automation and real-time responsiveness.

"By pushing 3D printable materials to their limits, we have exposed unexpected properties in the materials," says Dr Paul O'Dowd, Research Fellow - Creative Electronics and Engineering. "For instance, plastic deposition can be manipulated whilst it is hot and pulled into hairs, or fine gauss, or woven. Ceramics can also be deposited so that the material composition is capable of self-glazing in a single firing (as opposed to a multiple firing process). These material states may have applications in wider industry."

The task of robotically manipulating materials through complex states - for example, sensing and responding to viscosity - requires the integration of several advanced technologies. The MELFA robot allows real-time control and provides a reliable programming interface to allow this to happen. It also has a large area of reach and movement for a compact robot arm.

"The Mitsubishi Electric robot arm is very dexterous, allowing the robot to manipulate materials from all directions," continues O'Dowd. "Conventionally 3D Printers are machines with three linear axis (XYZ) and fabrication occurs in fixed horizontal layers. But the RV Series robot arm has both freedom of movement and a comprehensive set of expansion capabilities, including pneumatics and digital I/O, which are cleanly integrated into the chassis of the arm itself. This makes for an attractive combination of force control, movement range (908mm reach) and reliability, while also being at the right price point."

Proprietary software is being developed which must respond very quickly and dynamically to changes in the material’s properties and the construction of the printed object. This means that the control program

cannot be rigid in its operation. Instead it must constantly and iteratively interpret its working task environment and autonomously correct its behaviour.

Commenting on his selection of the Mitsubishi Electric robot, Dr O'Dowd said, 'We researched several robot manufacturers before deciding on the Mitsubishi Electric model, we were looking for flexibility of movement as well as an open programming environment. What really decided it for us though was the affordability of the robot package and the level of support provided by Mitsubishi Electric. We were invited to the UK HQ to assess a robot and have received excellent technical support throughout the project. As the robot is pushed further we will continue to call on training and advice as we need it.'

The Mitsubishi Electric robot proved to be an ideal tool to help create artistic objects using PLA (poly lactic acid), a bio-degradable type of plant-based thermoplastic used in 3D printers. The development team used the full extent of the robot's movement to push the material beyond its normal operating envelope and create new effects. The intuitive and easy to use programming interface meant that it worked well with software developed by the university team that altered the deposition speed to pull the material into fine filaments. The same set-up is planned to be used for developing artistic creations with ceramics and photo-cure resins, the production process for which could then feed-back to commercial industrial applications.

Further information:
You can learn more about this project by watching the video here: https://youtu.be/NxgeESWS3z0.

Note:

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Photo captions:

Picture 1: Dr Paul O'Dowd has been able to apply his own software application to push the creative aspect of the 3D printing process in order to create expressive designs.

[Source: Mitsubishi Electric Europe B.V.]

Picture 2: From left to right – Bob Lloyd, Business Development Manager- Mechatronics, Mitsubishi Electric Europe B.V., Dr Paul O'Dowd, Research Fellow - Creative Electronics and Engineering, The University of the West of England. Paul is holding the manual control pendant, which comes as standard with the MELFA RV-F Series robots.

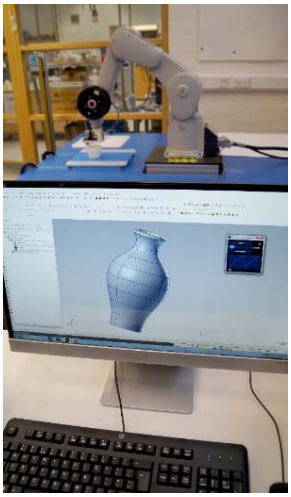
[Source: Mitsubishi Electric Europe B.V.]

Picture 3: A jpeg design image was converted into grey scale and a bespoke algorithm used to control the speed of the head based on image density. The process results in a reproduction of the image where the fine detail is unique every time the programme is run.

[Source: Mitsubishi Electric Europe B.V.]

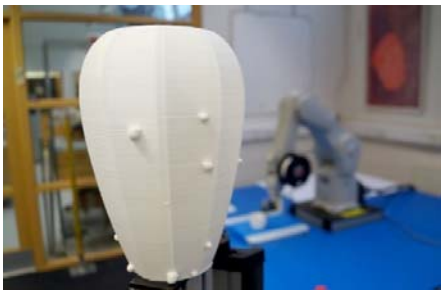
Picture 4: The robot uses polylactic acid (PLA) filament as it has a low melting point is also one of the more eco-friendly 3D printer materials available as it is made from corn-starch.

[Source: Mitsubishi Electric Europe B.V.]



Picture 5: The robot material deposition can be controlled using CAD models or flat images, the items are given a unique texture by manipulating the speed of the deposition.

[Source: Mitsubishi Electric Europe B.V.]



Picture 6: The vase shape was created during a public demonstration and the blobs show where the light curtain safety system interrupted the robot movement, effectively showing a time-line of interaction.

[Source: Mitsubishi Electric Europe B.V.]

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About the Centre for Fine Print Research

Established in 1998 and located in Bristol, at the University of the West of England within the School of Art and Design, the CFPR conducts internationally acclaimed practical research into the artistic, historical and industrial significance of creative print practices, processes and technologies, involving collaborations with a variety of practitioners, institutions and commercial users.

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**Exchange rate 112 Yen = 1 US Dollars, last updated 31.03.2017 (Source: Tokyo Foreign Exchange Market)*

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Press contact:
Mitsubishi Electric Europe B.V.
Factory Automation - European Business Group
Monika Torkel
Expert Marketing Communications
Mitsubishi-Electric-Platz 1
40882 Ratingen, Germany
Tel.: +49 (0)2102 486-2150
Fax: +49 (0)2102 486-7780
Monika.Torkel@meg.mee.com

PR agency:
DMA Europa Ltd.
Mr. Roland Renshaw
Europa Building, Arthur Drive, Hoo Farm Industrial Estate, Kidderminster, Worcestershire, UK
Tel.: +44 (0)1562 751436
Fax: +44 (0)1562 748315
roland@dmaeuropa.com
www.dmaeuropa.com