AM technologies

Fused Deposition Modelling (FDM)

The simplest 3D printing machines use a roll of plastic filament, which is fed continuously into a heated print head. The molten plastic filament is deposited on a platen to form the first layer. The platen is lowered sequentially as each layer is printed and as the plastic cools the layers fuse into a solid object. The printer software delivers instructions not only to create the 3-dimensional shape but also to print support structures under any overhanging parts of the object so that it does not distort during the manufacturing process. These support structures must be removed after printing.

Binder Jetting

Binder jetting machines use a gypsum-based powder, which is fixed by a liquid binder. A thin layer of powder (usually 100nm) is spread across a level surface and the shape of the object to be manufactured is printed in the same way as an inkjet printer, using clear and coloured binders. As each layer is printed the platform lowers by the thickness of a single layer until the object is complete. The finished model is removed from the printing compartment of the machine and the unused powder that surrounds it is carefully removed and recycled. This process produces a detailed plaster model in full colour. At this stage the model is soft and rather delicate to handle, so it is hardened using a cyanoacrylate infiltrant.

These 'ceramic' 3D prints are particularly suited to create anatomical replicas of bone and soft tissues that can be worked or used for forming metal surgical plates. They can also produce excellent replicas of light-scanned objects or computer-generated models in full colour and are therefore useful for teaching, training and display.

Stereolithography (SLA)

Stereolithography creates 3D objects layer by layer using a process called photopolymerization, by which light causes chains of molecules to link together, forming polymers. The commonest method is to use an ultraviolet laser to trace the pattern of each layer onto a liquid resin. Each layer hardens and fuses with the previous layer. Different resins are used to print objects with different material properties, such as colour, transparency, hardness, flexibility, heat resistance and biocompatibility. The latter property enables medical devices to be made that can be used in contact with skin or mucosa.

Selective Laser Sintering (SLS)

Laser sintering uses a powder in a similar way to binder jetting, but instead of a liquid binder, the powder layers are fixed by a high-powered laser. The laser traces a pattern over the thin layer of powder, melting it and fusing successive layers as it cools. This technology enables the manufacture of objects in materials such as steel, titanium and chrome alloys as well as plastics with specific properties. As with binder jetting, the unused powder provides support for the object as it is printed, obviating the need for support structures to be attached to the model and enabling clean finished objects to be printed.

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Factsheet

3D Printing and Visualisation

(Additive Manufacturing)

The terms 3D printing and additive manufacturing (AM) are synonymous, referring to a group of technologies for layered manufacturing, in which a solid object is printed one layer at a time. Media Studio's 3D Printing Lab produces 3D prints in a range of different materials and for different purposes.

The principal advantages of AM are that complex objects can be made directly from computer designs and that enables rapid development of prototypes or bespoke items. AM can also faithfully replicate objects that have been scanned, either with light scanning or medical scanners.

media studio

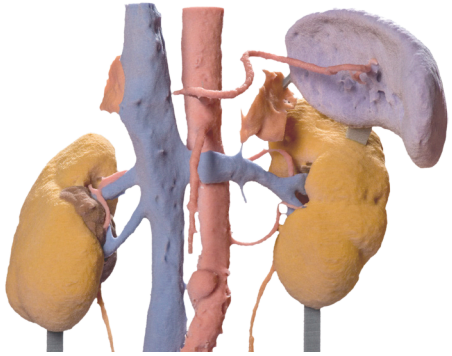
at the heart of the Cambridge Biomedical Campus

Surgical planning

3D models from CT scans are used for surgical planning and preparation. The CT scan is segmented to define the outline shape of the tissues of interest, creating a three-dimensional virtual model that can then be converted to a format suitable for 3D printing.

This method, combined with Media Studio's binder-jetting printer, is particularly suited to replicating bone and is used in cranial, maxillofacial and orthopaedic surgery. An accurate physical model of a patient's bones can be used to inspect the effects of trauma and disease and can be referred to during surgery, where soft tissues often obscure bony detail. These models are especially useful for plate forming and preparation in advance of surgery. They are hard enough to bend plates against the surface and can be cut or drilled to rehearse a procedure and ascertain appropriate cutting or drilling angles.

Soft tissue models are useful in other specialities, for example to examine complex vascular anomalies and to rehearse or train in procedures such as stenting, using patients' own scan data.



Surgical guides

New software tools are emerging to design surgical cutting and drilling guides. 3D printing enables these sterilisable and biocompatible devices to be designed using scan data to ensure that they fit the precise anatomy of a patient. They can help both in terms of accuracy and saving theatre time, by removing uncertainty about cutting and drilling angles or depths, and because they are relatively cheap to make they can be used once and discarded.

Teaching models

Models derived from patient scans enable students to work with replicas of real patient pathology in the classroom. Increasingly, these use materials that can mimic some of the properties of human tissue, such as flexibility in vascular models, or the hardness of bone. Handling full-colour 3D objects is much closer to the clinical experience than viewing images on screen. They can also be useful for demonstrating difficult concepts to patients in order to explain their condition and help to encourage compliance with treatment.

Display models

Full colour 3D prints, whether from scans or 3D artwork, make excellent display models for exhibitions, conferences and trade stands. This is a great way to display biomedical models, such as molecular structures and 3D electron microscopy.

Prosthetics

The advantage of AM technologies lend themselves to the manufacture of bespoke prosthetics, perfectly formed for a patient's precise anatomy.

Lab accessories and repairs

Plastic parts can be printed to repair or modify existing equipment around the laboratory.

Medical and surgical devices

One of the obstacles to the development of new or bespoke designs for medical and surgical devices is the cost of manufacturing prototypes and design iterations. Additive manufacturing makes it possible to substantially reduce the time and expense of making and testing prototypes. Media Studio is working closely with the Clinical Engineering Department to develop the practical workflows and governance arrangements to enable the in-house manufacture of items designed here. This approach presents an opportunity for innovation and cost saving for items that are produced in small quantities.

Bioprinting

This much-hyped technology will doubtless lead to some very exciting developments in 'spare part' surgery and medicine in the future. The process entails the use of stem cells to print human tissues in three dimensions, thus creating living tissues and organs from a patient's own cells for grafting or implanting. A considerable amount of research is under way in this field, but the technologies for developing complex living structures are still in their infancy.

Pharmaceuticals

As we learn more about the causes and preconditions of disease in individual patients the concept of bespoke medicine appears to be an attractive prospect.3D printing technology has the potential for producing medicines to individualised formulae; however, there are many practical, financial and ethical issues to resolve before we can expect to see patients enabled to print their own personalised drugs at home.

Research

We are keen to research both individual applications of AM in all fields of medicine and healthcare and the economic case for integrating the technology into routine patient care. We are currently involved in a study of the benefits of 3D printed models in scoliosis surgery and would be very interested to hear from anyone who would be interested in exploring other applications of 3D printing

Case studies

See the Media Studio website for news and examples of 3D printing in action: http://www.media-studio.co.uk/3d.