INTRODUCTION TO ADDITIVE MANUFACTURING

Problem Sheet 1

St Mary's University Twickenham London

SECTION A

Introduction to Additive Manufacturing

1. General aspects of additive manufacturing

(a) Define the terms additive and subtractive manufacturing, citing examples of both.

Answer: Additive manufacturing produces parts or objects by adding material as the part is built; it only uses just enough material to build the part. An example of additive manufacturing is fused filament fabrication. Subtractive manufacturing starts with raw materials and removes material from this raw block of material. An example of subtractive manufacturing is the production of parts using a lathe - the raw block spins and tools remove material from it to produce the require part shape.

(b) Give an application to which additive manufacturing is well-suited and stating your reasons why.

Answer: Additive manufacturing is well-suited to any application that requires customisation and produces parts in low numbers. e.g. printing prostheses or dental implants. additive manufacturing cannot at present compete in cost with mass-production techniques. An interesting exception to this is when additive manufacturing is used to produce parts for another production process e.g. casts.

(c) What are the implications of additive manufacturing for commercial manufacturing and industry?

Answer: Digital transportation of goods to the consumer leading to cheaper supply costs and benefits for the environment. A more detailed discussion is given in Fabrication (the grey book).

2. Design and commercial implications of additive manufacturing

(a) Are you able to sell printed items from a design sharing website, such as Thingiverse, on Ebay? Why not?

Answer: It depends whether the license permits commercial use. Example licenses that permit this include a number of Creative Commons licenses (CC-BY, CC-BY-SA, CC-BY-ND...). Factors to consider when choosing a license include whether you wish derivatives to have the same licensing (CC-BY-SA), whether you would like no derivatives or not (CC-BY-ND), permit commercial purposes or not (CC-BY-NC).

(b) You run a successful toy company that has for many years produced small superhero figurines which are well-liked by a community of fans. You see the rise of 3D printing as a threat to your business as now many people can afford to scan and reproduce your figures (without buying them from your company!). How would you protect your business from this loss of revenue? What would you do to engage with this new market of fans with 3D printers?

Answer: Potential options to engage the community include: produce official models with no-derivatives, no-commercial aspects of licensing, update figurines to have details finer than the typical feature resolution of printers, produce modular and official figurines that allow the community to rehash and design new figurines. If all fails, employ litigation.

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(c) As a hobbyist-designer, you would like the community to be free to use your design and all of its derivatives, attributing you appropriately, and for non-commercial use only. Which type of copyright license would you choose?

Answer: CC-BY-NC-SA - allows others to build upon the model non-commercially with suitable attribution to you.

SECTION B

The Generalised AM Process

1. Describe the steps involves in producing a printed item.

Answer: See the relevant chapter in Gibson

2. What types of information do STL and g-code files hold?

Answer: STL files contain the surface mesh of the model decomposed into a number of triangles. G-code files contain instructions to the printer for its set-up and movements.

3. Explain why the ratio of the number of faces to the number of edges in a STL file is 1.5, if the mesh is watertight.

Answer: Draw a triangular mesh and consider the three edges of a singular triangle. These edges are each shared between two triangular faces so there are 3/2 edges for the single triangular face; or mathematically, $F/E = 1.5$, where F is the number of faces and E is the number of edges.

4. Annotate each line of the following g-code with the corresponding action by an fused filament fabrication printer. At what stage of printing do you think that this code will be executed. You may use a g-code "cheatsheet".

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G28 X0 Y0
G1 Z150 F300
M104 S0
M140 S0
M84
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Answer: G28 X0 Y0 - Zero the axes
G1 Z150 F300 - Move to Z=150 and set the feedrate to 1500mm/min (irrelevant)
M104 S0 - Set the extruder temperature to zero
M140 S0 - Set the bed temperature to zero
M84 - Stop/Idle/Hold - stops everything.
This could be used at the end of a printrun.