FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
FUTO - BREDHUB ARTIFICIAL INTELLIGENCE (AI) AND ROBOTICS

COURSE TITLE: INTRODUCTION TO 3-D PRINTING

COURSE CODE: BRC-FUTO-002

COURSE OUTLINE:

1. History of 3-D printing
2. Definitions of terminologies
3. What is 3-D printing?
4. Advantages and limitations of 3-D printing
5. Types of 3-D printers
6. Resources needed to 3-D print
7. Installation of IDE's for 3-D printing

(i) DOBOT STUDIO
(ii) ULTIMAKER CURA
(iii) BLENDER

8. Steps in 3-D printing technology
9. 3-D printing application fields, examples
10. Practical;

A.

(i) Download of 3-D CAD file online
(ii) Slicing of STL file
(iii) Setting up 3-D printer
(iv) 3-D printing

B.

(i) Designing of 3-D object in Blender

(ii) Exporting STL file from Blender to a slicing software

(iii) Slicing STL file for printing

(v) 3-D printing

LECTURE NOTES:

History of 3-D printing:

In 1980, Dr. Hideo Kodama, a Japanese 'patent lawyer' was the first to describe a layer-by-layer addition of materials to create a solid object.

This idea then, was referred to as ''**RAPID PROTOTYPING'**'. As it was easier and faster for them to create prototypes or look-alike of objects for experimental purposes.

However, Dr. Hideo Kodama failed to complete the filling for the patent before the one-year expiration. Hence, he was not given the patent but this his discovery gave the back ground for what is known today as Selective Laser Sintering, another type of rapid prototyping method.

Alan Herbert followed Dr. Hideo Kodama's path of producing parts using the additive method of production (AM) in 1981.

Charles Hull (a.k.a Chuck) in 1984 filled a patent for **STEREOLITHOGRAPHY APPARATUS (SLA)**.

In 1986, Charles Hull was given the patent for "**Apparatus for the production of three-dimensional object by stereolithography".**

The world's first rapid prototyping system, the **SLA-1** was introduced in the year 1987 by the company called 3-D Systems.

At the University of Texas, Carl Deckard was issued a patent for **SELECTIVE LASER SINTERING (SLS)** rapid prototyping process in 1989. In this 3-D printing technology, powder grains are fused together locally using **LIGHT AMPLIFIED** by **SIMULATED EMISSION** of **RADIATION** (**LASER**).

In the year 1991, STRATASYS produced the world's first **FUSED DEPOSITION MODELING (FDM)** or **FUSED FILAMENT MODELING (FFM)** machine which uses an extruder and plastic to deposit layers of melted plastic on a print bed.

The patent for the FDM 3-D printing technology was issued to STRATASYS in 1992 and this enabled them to develop many 3-D printers for both professionals and individuals.

DEFINITION OF TERMINOLOGIES**:**

1. Axes (X, Y, and Z)
2. Three Dimension (3-D)
3. Computer Aided Design (CAD)
   This is a drawing done using a computer system.
4. 3-D Design

5. Computer Numerical Control (CNC)

Computer Numerical Control is the use of computer program to instruct a machining tool to carry out processes of materials (plastic, metal, wood, ceramic, or composite) to meet specifications without a manual operator directly controlling that machining process.

6. G-Code

G (geometric) codes are the commands that has to do with the motion or positioning of the end effector relative to the workpiece, which is usually found in or on a manipulator.

Examples of G-code are;

G00
G01 X(40) Y(21) Z.1
G01 X(40) Y(21) Z.1 R5

7. M-Code

M (miscellaneous) codes are instructions for machine functions like speed, coolants (e.g., fan) and so on.

Examples of M-code are;

M0
M1
M 201

8. Slicing

Slicing is the use of computer software to convert the CAD object which is in STL file format into layers(slices) so that the system will be able to associate geometric locations to lines of the shape of each layer.

Examples of slicing software are;

ULTIMAKERCURA
SLIC3R
REPETIER
BLENDER

9. Build platform

Build platforms is the surface on which the printed materials will be deposited to keep the object being printed warm so that it does not cool unevenly. It is sometime a heated metal bed or glass.

10. Extruder

Extruder is the part of the 3-D printer that consists of the cold part to pull in the build material and a hot part to melt the and pour out the build material.

11. Nozzle

Nozzle is a brass or steel funnel-shaped die through which the melted build material comes out.

12.Filament

Filament is here is a thermoplastic made into a continuous wire and wound onto a spool to make it compactible with the extruder of the 3-d printer's system.

The size designation of a roll of filament (Filament Diameter) is usually 1.75mm 0r 3mm.Also, 2.85 mm and 3mm are in the same category and can be used interchangeably.

13. Extruder Motor

An extruder motor is a stepper motor that guides the filament into the hot end of the extruder.

14.Support

These are additional removable structures that are printed to assist overhang or other part(s) of the model that do not contact with the build platform when printing.

15.Stereolithography (STL) file the recommended file for 3-D printing.

WHAT IS 3-D PRINTING?

3-D printing is an additive method of manufacturing in which a three-dimensional solid object is constructed from a CAD design model or a digital 3-D model.

This is achieved by stacking 2-D layers to form three-dimensional objects.3-D printing is also referred to as Additive manufacturing since it also uses the layer-by-layer method of production to deposit materials as against the traditional subtractive method of production. Each layer is a thin sliced cross-section of the 3-D object.

Advantages and limitations of 3-D printing

A. Advantages

1. SPEED

Speed is one of the most important advantages of 3-D printing. This is the reason why those that worked earlier on this method of production called it "**RAPID PROTOTYPING**". It has the ability to design and manufacture parts in as less time as possible, while also making

sure that there could be easy modifications to the design without a considerable loss of production time.

2. **INCREASED CUSTOMIZATION**
   The layer-by-layer printing of an object from an existing design (or blueprint) allows for an unlimited customization of products.

3. **IMPROVED SMALL-SCALE BUSINESSES**
   Small- scale businesses have benefitted tremendously from 3-D printing. With as little as $300, a 3-D printing enthusiast can get a 3-D printer and avoid constraints from contractors. Also, there is room to freely create, print and sell whatever to whoever he or she wants to.
4. **HARDWARE REQUIREMENT**
   Less hardware is required for production that is not too big.

5. **ACHIEVING COMPLEX DETAILS**
   With the use of 3-D printers, details of complex exterior and interior or combination of separate parts can be done easily.

6. **HIGH SUSTAINABLE**
   Most of the materials used for printing in 3-D are recycled materials. Objects are built from scratch layer-by-layer, thereby reducing waste. Hence, its high sustainability.

7. **RARE OR ONE-OFF PRINTS**
   One can 3-D print rare replacement parts. Also, making a one-time part is also made possible using 3-D.

8. **EASY ERROR DETECTION**
   Since parts are printed bit-by-bit, it is easier to detect errors or mismatches. Therefore, increasing consistency and reducing the number of failed parts.

9. **FLEXIBLE MODIFICATION**
   In other methods of production, an alteration in the mode of the intended build will require a change in tool but for 3-D printing, as long as the modified build fits the maximum volume, we are good to go.

10. **CREATING GEOMETRIES**
    Difficult geometries which other manufacturing processes cannot create as a single piece or at all can be created using 3-D.
11. **LIMITED CAD KNOWLEDGE**
    There is little or no CAD knowledge required to design, modified, and print using 3-D printing method. A little knowledge is needed when one wishes to make a product unique.

12. **AUTOMATED PROCESS**
    3-D printers are fully automated and require very little personnel to supervise.

13.EASILY ACCESSIBLE

A large number of people can readily get 3-D printers, thereby, making it easily accessible to many intending users.

LIMITATIONS OF 3-D PRINTING

1. **HIGH ENERGY CONSUMPTION**
2. **COSTLY TECHNOLOGY**
3. **SCARCITY OF PRINTING MATERIALS**
4. **HARMFUL EMMISIONS**
5. **PLASTIC DEPENDENCY**
6. **SLOW SPEED IN MASS PRODUCTION**
7. **ILLEGAL WEAPONRY**
8. **PATENT VIOLATION**
9. **JOB LOSS**
10. **TIME CONSUMPTION**
11. **COLOUR LIMITATION AND FINISHES**
12. **LIMITED ENDURANCE**
13. **PARAMETRE SETTINGS AND DESIGN SKILLS**
14. **SIZE LIMITATION**

TYPES OF 3-D PRINTING TECHNOLOGY

There are different types of 3-D printing technologies and among them are;

1. Fused Deposition Modelling (FDM)
2. Stereolithography (SLA)
3. Digital Light Processing (DLP)

4. Selective Laser Sintering (SLS)
5. Selective Laser Melting (SLM)
6. Laminated object Manufacturing (LOM)
7. Digital Beam Melting (EBM

TYPES OF FDM 3-D PRINTERS

FDM printers are the most common 3-D printers among individuals and 3-D printing hobbyists. Therefore, we will focus on FDM printers now. There are four major types of FDM printers and they are;

1. Cartesian
2. Delta
3. Polar
4. SCARA

CARTESIAN FDM PRINTERS

This is named after the mathematical co-ordinates; X, Y and Z (the cartesian co-ordinate system discovered by Rene Descartes in the 17th century.