Experimental researches concerning the manufacture of multitool 3D printer, type DIY (do it yourself)

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Abstract. In the last decade, additive manufacturing has greatly developed and the manufacture of cheaper 3D hybrid (multitool) printers has increased. Hybrid 3D printers are equipped with interchangeable heads for manufacture and permit multiple types of processing such as 3D printing, CNC cutting, laser engraving or deposition of pasty materials. The objective of this paper was to manufacture a hybrid 3D printer prototype, type DIY (do it yourself) and was equipped with g-code software necessary for 3D printing process and for CNC cutting. The materials used for construction for this hybrid 3D printer are cheap and accessible and some of electronic components are reused and recovered from old equipment and the functional 3D hybrid printer obtained can be a model for sustainability of products.

1. Introduction
The purpose of this research was to create a hybrid 3D printer prototype, recycling and recovery of old electronic components, such as were used stepper motors from some old Xerox equipment, enabling sustainable development of the product. Hybrid 3D printers are multifunction printers that will replace traditional 3D printers in the future or min-CNC and will be finding in most households, because of their varied functionality. A hybrid 3D printer ZMorph is presented in figure 1 [1].

Hybrid 3D printers are equipped with several interchangeable heads: as simple 3D print head, 3D dual head, CNC head, laser engraving head and ceramic material deposition head.

Fused Deposition Modeling technology (FDM) uses a variety of filament-like materials of PLA, ABS, nylon, etc. [2] The mechanical strength of the manufactured parts is very good, often existing 3D printers that are sold with 3D printed components in their composition [3]. Hybrid 3D printers used this technology for printing 3D parts.

The mechanical strength of the 3D printed parts is very good, often existing 3D printers that are sold with 3D printed components in their composition [4].

The hybrid prototype 3D printer made in this research also has in its composition, 3D printed parts, 3D printed directly on itself, like the red brackets of the printed table and the head CNC components.

FDM technology is based on the materialization of a CAD product by adding successive layers. The object is saved in the stl. file to be used by 3D printer software. This technology permits the supports building necessary for the 3D printed parts [2, 3].

The prototypes obtained by FDM technology, do not require any additional post-processing treatments and can be used immediately, presenting a high quality surface [5].

The Additive Manufacturing technology helps identify any problems that may arise in the design and conception [6, 7].
ZMorph printer can print layers up to 50 microns. ZMorph 3D hybrid printer is equipped with five interchangeable heads allowing printing, milling, drilling and engraving materials widely. The manufacturing dimensions of ZMorph printer are 300x235x165 mm. The manufactured materials of this printer are very different from PLA, ABS, special filaments wood, etc. The software used of this printer is Voxelizer. The price of a hybrid 3D printer is quite high, around 4000 euros. This research tries to realize a low cost hybrid 3D printer, around 500 euros, that will be using for didactic and researches experiments [8, 9].

2. Experimental researches
The experimental research consists to manufacture a hybrid 3D printers DIY (do it yourself), low cost, using readily available cheap materials and tools.

**Figure 1.** Commercial 3D hybrid printer ZMorph. [1]

**Figure 2.** Structure design of 3D printer.

**Figure 3.** Assembly and welding of 3D printer parts.
In the design stage, it was considered the sizing of structural elements depending on the size of standard components used (clamps catching SK10, SK16, bearings SC10UU, linear guide Ø10, motors NEMA17) in construction of 3D printer structure, which will be manufactured in welded rectangular profile 20x20 mm, as follows in figure 2 below.

In figure 3, it was realized the cutting and drilling plates of PTFE material which will form the printing table, it has been the attaching of the stirrups and linear guides, to the fixing table and uncoupling the bed springs and adjustable thumbscrew to facilitate leveling.

It made cutting boards and were positioned linear bearings. NEMA17 motors were attached and completed the construction.

Concerning the electrical connections, it has realized different connections between controller and stepper motors. In order to achieve electrical control network used: a development board - Arduino MEGA 2560, a 1.4 Ramps SHIELD module, 5 Drivers 4988, as in Fig.4.

In figure 5 is presented the electrical installation scheme. It used a power supply PC PSU 12V 14.6 and an endstop with mechanical feeler as in figure 6 and figure 7.
The single-pole stepping motors with 4 phases have been converted into 2 phases by eliminating "the mid-point" of the coils A and B (MA:MB), as in figure 8.

![Figure 8. Stepping motors.](image)

For 3D printer operation was performed scheduling and optimization software. Implementation of physical parameters of the printer was done using Marlin1.1 code as in figure 9, uploaded on the development board Arduino MEGA 2560.

```c
// Default Axis Steps Per Unit (steps/mm)
// Override with N202
%X, Y, Z, E0 [, E1[, E2[, E3[, E4[]]]]]
#define DEFAULT_AXIS_STEP_PER_UNIT  [89, 100, 1600, 94.3 ]

// Default Max Feed Rate (mm/s)
// Override with N203
%X, Y, Z, E0 [, E1[, E2[, E3[, E4[]]]]]
#define DEFAULT_MAX_FEEDRATE  [396, 309, 5, 28 ]

// Default Max Acceleration (change/s) change = mm/s
// (Maximum start speed for accelerated moves)
// Override with N201
%X, Y, Z, E0 [, E1[, E2[, E3[, E4[]]]]]
#define DEFAULT_MAX_ACCELERATION  [2600, 2600, 2600, 10000 ]
```

![Figure 9. Marlin1.1 code used for 3D hybrid printer prototype.](image)
With its aid were set issues, like in figure 10:
- Port for the connection;
- Extruders number;
- Existence heated bed;
- Thermistor type used (100K);
- Maximum axes travel;
- Required number of steps per mm (the pitch of the threads);
- Point0 (homing point);
- Size table printed, as in figure 11;
- Maximum acceleration, as in figure 12;
- Maximum voltage motors.

```
#define X_HOME_DIR -1
#define Y_HOME_DIR -1
#define Z_HOME_DIR -1

// @section machine

// The size of the print bed
#define X_BED_SIZE 260
#define Y_BED_SIZE 260

// Travel limits (mm) after homing, corresponding to endstop positions.
#define X_MIN_POS 0
#define Y_MIN_POS 0
#define Z_MIN_POS 0
#define X_MAX_POS 260
#define Y_MAX_POS 260
#define Z_MAX_POS 260
```

**Figure 11.** Size table printed programming.

```
#define DEFAULT_ACCELERATION 2500 // X, Y, Z and E acceleration for printing moves
#define DEFAULT_RETRACT_ACCELERATION 3000 // E acceleration for retracts
#define DEFAULT_TRAVEL_ACCELERATION 2500 // X, Y, Z acceleration for travel (non printing) moves
```

**Figure 12.** Maximum acceleration programming.

G code can be obtained using various programs using models in a "Stl" as: Slic3r and its extension Pronterface or Simplify 3D, both programs also providing a good calibration printing parameters (printing speed, infill, thickness the outer walls, the height of the layers, the width of the filament, temperature) shown in figure 13. In figure 14 are presented the physical 3D parts obtained by 3D printing using the 3D hybrid printer prototype.
Figure 13. Simplify 3D program used to create g-code's.

Figure 14. Physical 3D printed parts.
In figure 15 are shown the components of the hybrid 3D printer. In figure 16 are presented the exchangeable CNC tool head, some components of them are manufacture by 3D printing. In figure 17 is presented the CNC drilling on the 3D hybrid printer, using the CNC head.

![Figure 15. Components of hybrid 3D printer.](image1)

![Figure 16. CNC head of 3D hybrid printer.](image2)
Figure 17. CNC drilling on the 3D hybrid printer.

3. Conclusions
This article presented the practical realization of a hybrid 3D printers DIY (do it yourself) using existing tools and inexpensive materials in any household.

Some of the elements used in hybrid 3D printer were recycled from old electronic equipment; this may lead to the sustainable development of the product.

Hybrid prototype 3D printer made in this research has been done on a low budget and is equipped with simple 3D print head and CNC head. The software used to perform the G-code has been Simplify 3D. The innovative part of this research was the electronics, the programming and optimization software. The dimensions of pieces manufactured by this 3D hybrid printer are 300x300x200 mm, having a very well precision of 0.2 mm.

4. References
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