Adaptive layer thickness

Adaptive infill density

Visual based filament clogging and exhaustion detection in fused deposition modelling 3D printers.

Smoothness finder python GUI

Abstract

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Literature review

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Literature review.

Consistent growth of additive manufacturing leads to invention of various problems and its subsequent solutions for it. Lots on self-contributors are owning DIY 3D printers are customizing the printers and fortunately provides various new invention contributing its global growth.

Reviewing the paper entitled vision based error detection, which proposes the system of identifying the filament ran out issue in another novel approach of taking camera snap of the print area and analysis the footage using image processing algorithms and detect the failure of extrusion and just stops the printer after several consecutive layers. Hence causing the wastage of machine run time. The inefficient of the detection time capability causes the delay in the system.

The system detects filament ran out issue with computer vision

The proposed novel approach focus to figure out filament ran out challenges with minimal possible time in order recover the problem automatically. Since currently viable solution mainly focusses only on saving the filament once the printing fails and stops machine accordingly. Following solution capable of detecting filament’s constant flow along with automation of defined scripts directly in the hardware.

Machine setup

For testing Ender 3D machine has been used.

Camera used

Microsoft LifeCam HD-3000 Web Camera HD 720P PC WebCam USB Windows XP,7,8 NEW

Connectivity Technology    Wired  
Dimensions (WxDxH)    4.5 cm x 3.9 cm x 10.9 cm  
Weight    90 g  
Camera    Colour  
Optical Sensor Type    CMOS  
Focus Adjustment    (min distance 30 cm )  
Interfaces    Hi-Speed USB  
Digital Zoom    4  
Audio Support    Yes : built-in microphone  
Features    720p HD movie recording, 16:9 widescreen mode, Skype compatible, TrueColor Technology  
Cables Included    1 x USB cable - external - 1.8 m  
System Requirements    Microsoft Windows 7, Microsoft Windows XP SP2 or later, Microsoft Windows Vista  
Microsoft Certification    Compatible with Windows 7  
Environmental Parameters (operating)    0 °C ... 60 °C ; 5 - 95% (non-condensing) relative humidity

Setting up

The camera unit installed parallelly to the printer nozzle end and kept aligned I such way focussing extrusion until bed. Small 3d printed components serves the need of holding the camera in the position. Figure XX shows the mounted camera module in the ender 3d printer subjected to testing.

Along with the setup steel brush has to be fitted with bed platform which supports the nozzle to get blur free. Fitting enabled by clamp mounting to heated bed and the coordinates are noted.

Figure XX shows the position of the clamped brush along with the heated bed.

Open source firmware Marlin has been used in this work which supports dual extrusion also.

GCode setting for machine.

While pausing we need the machine to be settled at the home position and either waits for manual intervention or can automatically loads filament from the next spool.

Gcode is nothing like the machine code which has been used to control the machine.

Pausing

Resume

Home

Nozzle cleaning

Extruder reload

Return to job

Problem identification

Though there are various solutions coming up in hardware level, they are not efficient in full filling the conditions. Hence in order to provide efficient solution software integrated solution will be best suitable. This also reduce additional hardware’s which needs to be installed other than camera unit. Considering the FDM printers various such as filament clogging, wrapping, over extrusion, under extrusion, printing offset, oozing, temperature issue, deformed infill, support fail, filament bridging and many other issues occur in 3d printing machine. Among these we have identified three common issues such as ran out of filament, filament clogging, under or over extrusion & filament oozing.

Common occurrence of these problems occurs because,

Filament running out which cause because of manual error where operator fails to load required amount of filament spool. Easy way to solve this is with help of slicing software which estimates the amount of filament required mostly in grams. Even some times the issue occur due to mechanical failure of extruding setup where pushing head loosen or the guide holder get removed from its position. Another rare case of grinding of filament by feeder mechanism roller instead of feeding it, which occur due to the cool hot end. Due to cool hot end the filament struck at nozzle tip and causes the grinding effect. Anyhow for these simple IR sensor integration serves the purpose which will monitor the flow, other than manual intervention is required.

But the vision based solution always serves accurate and viable solution hence the same camera unit can be utilized for various other detections as well. Another issue of under and over extrusion appears when the flow rate fails to function properly. If the system over flows then over extrusion occurs when the flow rate reduces then under extrusion occurs. This ends in improper layers causing the models failing to serve purpose. Mechanical it becomes hard to detect the issue and provide the solution, and needs human support to solve the issue.

Conclusion

The above novel method of approach provides the solution to figure filament ran out issue using the computer vision method. This camera unit not only capable of providing the solution for the stated problem but also addresses various problems such as over extrusion, under extrusion, filament misalignment and can feed the live to web which allows the owner to continuously monitor the system. The concept works fine with marlin firmware and making few functional changes permits to operate across various firmware as well. Considering the market growth of 3D printers these solutions will make the technology more reliable and efficient and provides inevitable standards for this additive manufacturing. Not only for fused deposition modeling but also this concept can be applied for other additive manufacturing technologies. Ultimately solution reduces material wastage and save a lot of time if any error occurs in the system.

Machine interruption system

The second phase of this work is the machine interruption system (pause) subsequent to the status of the extruder procured from the first phase (Vision sensing detection) for efficient printing. To accomplish this we have written certain conditions which is considered as Serial Intrusion algorithm to perform specific defined states of printing process such as pause, resume and stop amid printing. Serial intrusion algorithm overrides the Gcode sender script which is sending commands asynchronously along the tty port, to pause the printing process if the extruder status is 1 (No Filament). This work also facilitates sending of explicit Gcode during this state further to check for the filament flow anew with a trance time of 5 seconds. If the status of extruder changes back to 0 (Filament), the printing process is resumed at the exact layer and position without human interference.

CAD Model being designed in any viable designing software is being converted to stl (Standard Triangle Language) format since it is the standard input model format in almost all 3D printers.

Fig xx shows the CAD model and corresponding converted .stl file.

This file conversion depends upon various criterions such as layer height, filament diameter, machine work volume, travel speed, extrusion speed, and much more will be considered. Few open source software even allow slicer to auto create support when the angle of inclination is below 45 degree (defined as ideal condition).

5.1 Slicer software

Numerous open source Slicer softwares such as CURA, Slic3r, Craftware etc. are available widely. Among them this work rely on CURA Slice Engine considering the versatility and the community support. Commencing the system requires a software to feed the machine parameters and certain functionalities including the machine’s serial responses such as machine motion coordinates, bed temperature and other coherent data both at the transmission and the receiving end. In this system we are using the RepetierHost platform as a exhibiter. From the CAD model various algorithmic approaches are available to slice the model. Usually slicing performs two operations (i.e.) detecting the contour and generating the infill pattern among the contour. There are various infill patterns such as grid, honeycomb, star, diagonal, etc to serve various purposes.

Fig xxx shows CAD model being sliced

The workflow for slicing mostly depends on the path tracing algorithms which commonly separates 3D design into 2D layers and stacking one over another. The corresponding flowchart is shown below in fig xx.

Choosing Z coordinate

Mesh slicing

Contour construction

Determing polygon assembly

So once the slicer completes slicing, it create file with extension .gcode which represents GCode file. This file usually comprises of two sets of commands starting with either G or M. Where the G code usually represents the code relevant to movements of the positioning actuators where as M code usually represents the functions of the machines.

For example

G28 X0 Y0 Z0 E0.0

Here G28 - stands for Home axis

X0 - X Coordinate to 0

Y0 - Y Coordinate to 0

Z0 - Z Coordinate to 0

E0.0 - E Extruding 0.0mm filament

Similarly for MCode

M106; Turn fan on

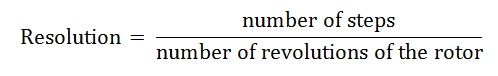
M107; Turn fan off

So the output from slicer software will be a set GCodes and MCodes according to the machine settled up. Once these are generated it can be sent via slicer software or through SD Card to the firmware.

5.2Firmware

Firmware is the one which connects the hardware and software thereby facilitating as a bridge. The firmware plays the major role in controlling the functionality of 3D printers from converting GCode to motor signals, controlling heat ends and heat bed, operating LCD display and much more machine akin functionalities. Abundant firmwares are available which corresponds to the control board in the machine. Various firmware like Marlin, Repetier firmware, Reprap, Smoothieware are available as open source. For this proposed work Repetier host has been adopted since the Repetier host and Repetier firmware works well with each other.

Once GCode is received, the defined 8 or 16 or 32 bit processor starts processing the code and adds it in the queue inside the sump to feed the printer. This will convert the Gcode into electric pulses which actuates the motor. The Stepper motors in the printer could able to count the rotations performed with the minimum step angle. For example



The above stated relation is used to figure the resolution of the motor, smaller the step angle more the resolution. In this case the angle is 1.8 degrees which has 200 steps per resolution which is nominal. Then comes the mechanical structure which defines the movement and transfer of rotational motion into linear motion in the motors. Various transfer methods can be achieved using different setups such as belt drive, screw drive, etc. In this work, we use 2mm pulley teeth belt. Simple mechanical calculation of the motor pulley diameter, and belt dimension gives the number of rotations required to move the quantified distance. All these calculations are performed by the control board and these criteria must be preloaded in the firmware.