Development of a Software for the Design of Electronic Circuits in 3D-Printable Objects

Colloquium - Bachelor Thesis

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Introduction

- Integration of conductive traces in 3D printed objects shown by [Palmer et al., 2004]
- Next step is 3D electronics
- Print entire product instead of assembling it

Problem

- Working printer already exists [Wasserfall, 2015]
- There is no software to design 3D electronics properly
- All circuits are designed in a 3D CAD software
- A suitable software to design 3D electronics is needed

State of the Art

CAD Design

- Design whole circuit in 3D CAD software
- Save as STL for print
- No reference to electronic parts
- Very complex process
- Good to test first printer prototypes

State of the Art

PCB Design with CAD Support

- Design circuit in PCB design software
- Transform the circuit with 3D CAD software
  or
- Stacking multiple circuits with 3D CAD software
- Save as STL for print
- No real 3D circuits

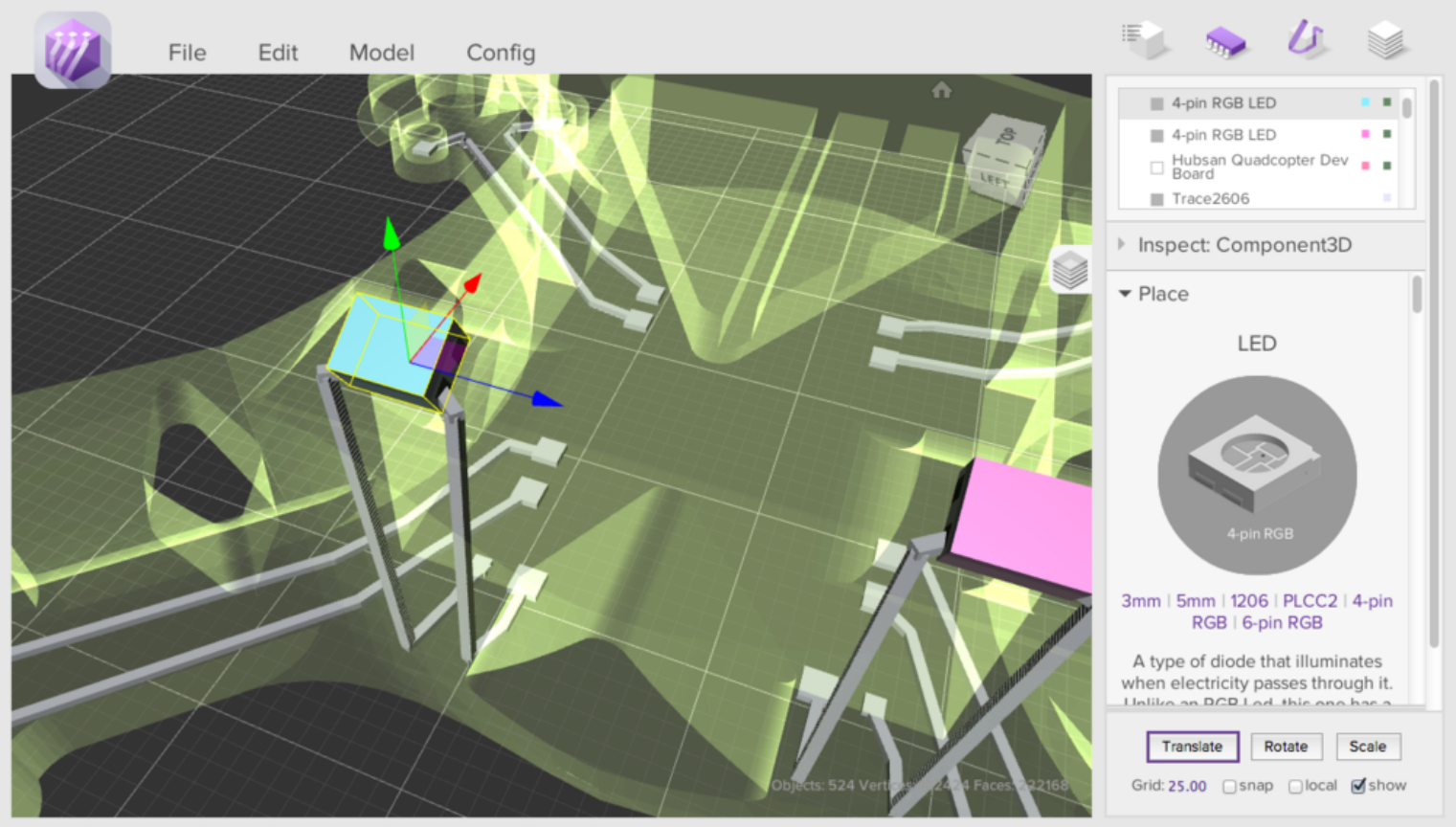
State of the Art

Autodesk Project Wire

- 3D electronics design tool
- Commercial software
- Cloud software
- Autodesk toolchain has to be used
- Not released yet

State of the Art

Autodesk Project Wire



Autodesk Project Wire [Autodesk, 2015]

Selected Method

3D Electronic Design in Slicing Software

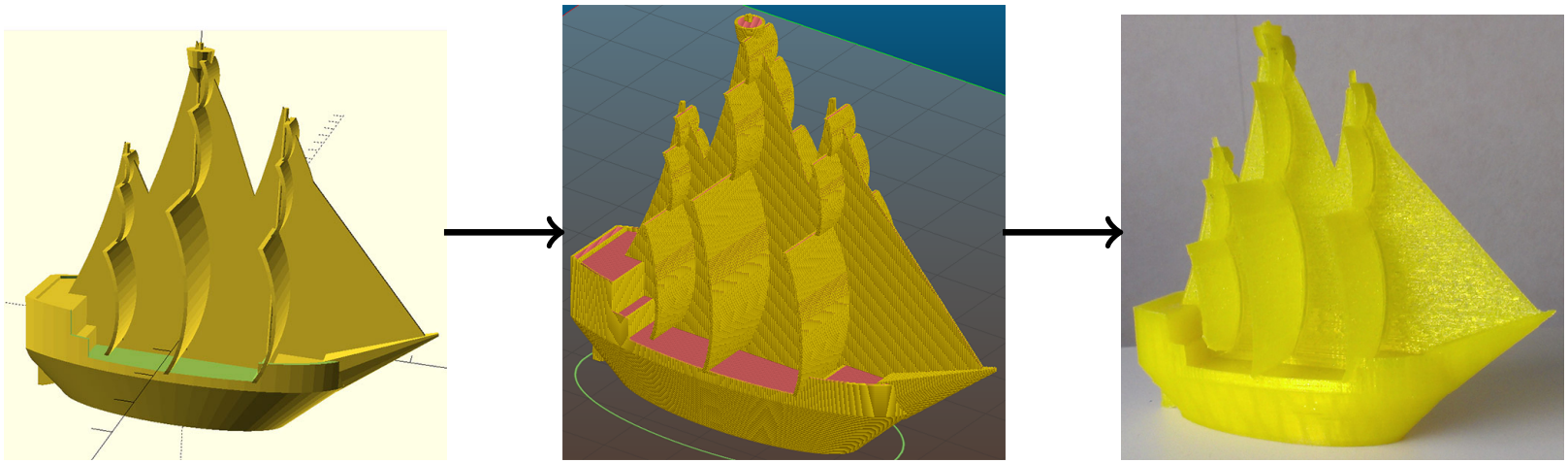
- Create circuit schematic in PCB design software
- Import the schematic in slicing software
- Place electronic components
- Slicing software has to be modified
- Can create real 3D electronics
- Components can be placed regarding to the layer structure

Selected Software

- CAD software is fully exchangeable
- PCB design software Eagle
- Slicing software Slic3r

Integration in Design Process

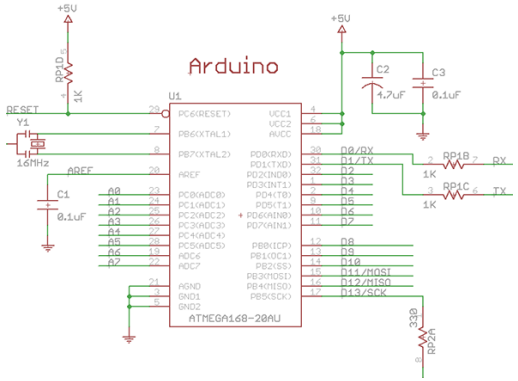
3D Printing Process



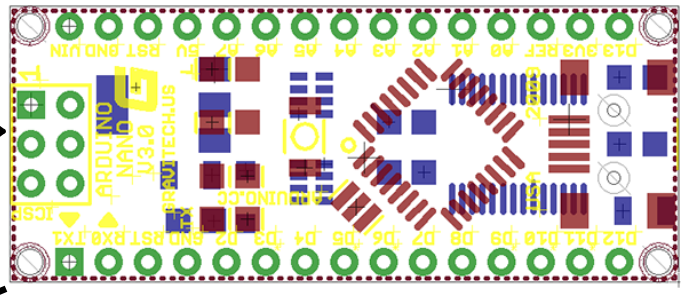
(a) Model design (b) Slicing (c) Printing

Integration in Design Process

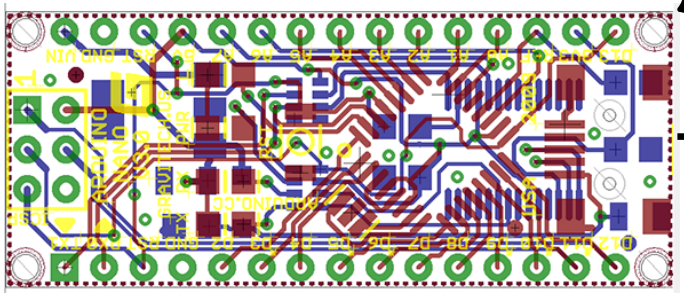
PCB Design Process



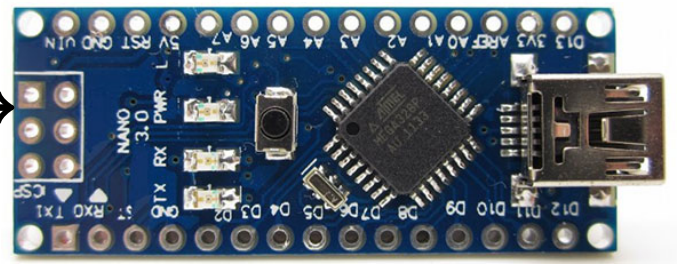
(a) Schematic design



(b) Placement



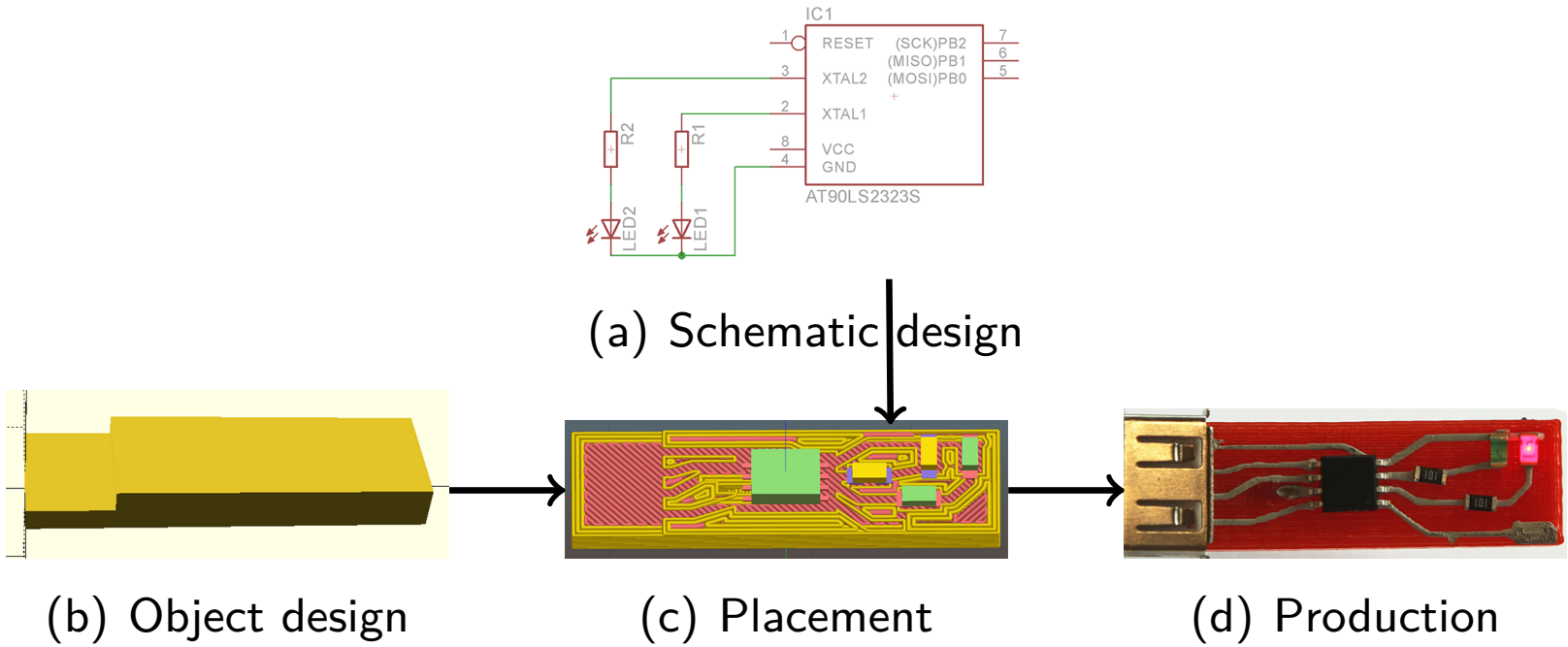
(c) Routing



(d) Production

Integration in Design Process

3D Electronics Design Process



(a) Schematic design

(b) Object design

(c) Placement

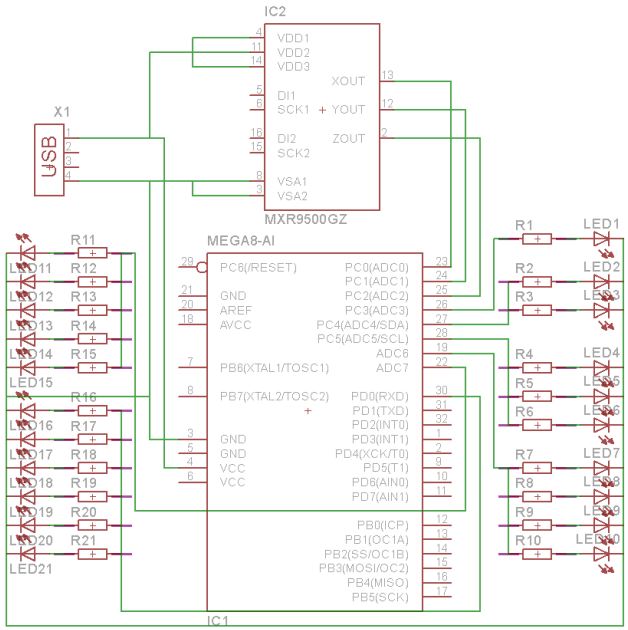
(d) Production

Live Demonstration

☞ Demo

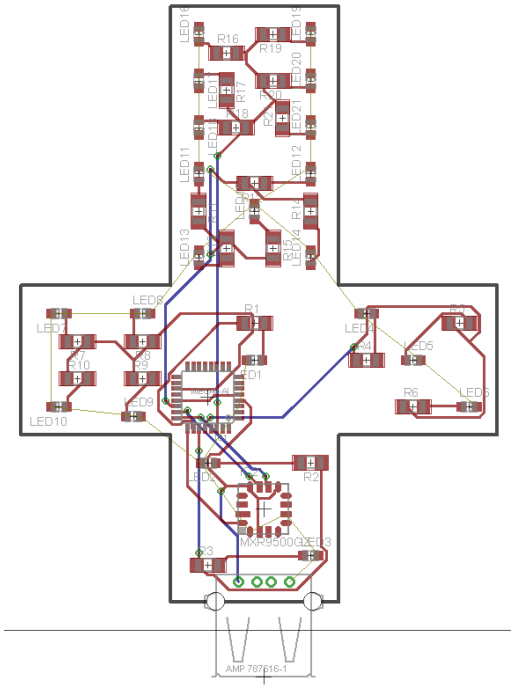
Design Test

- Test the design efficiency
- Place components with Eagle and the modified Slic3r
- Circuit is a die with LEDs on each side



Design Test

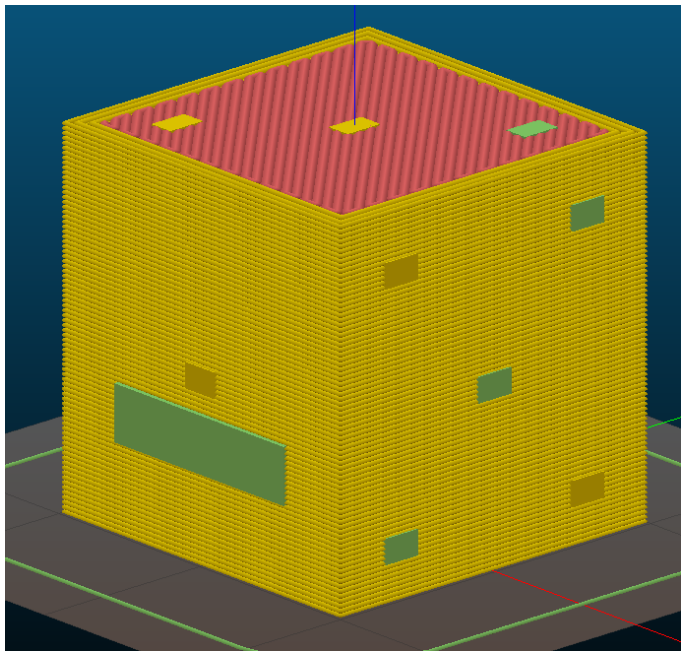
PCB Design Software

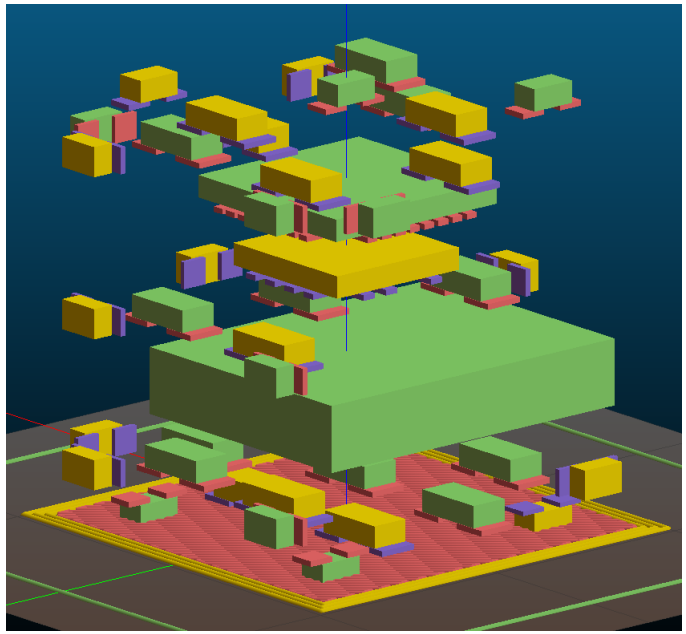


17 minutes without wiring

Design Test

Modified Slic3r





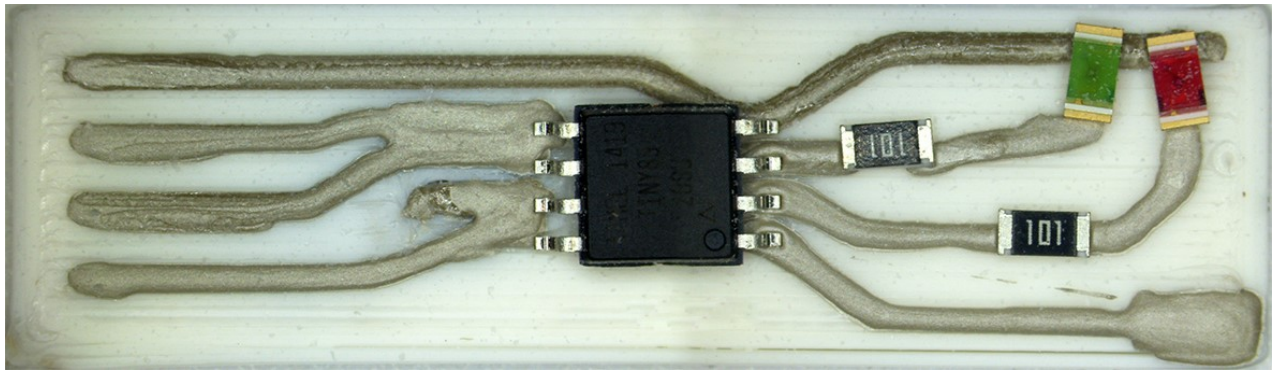
23 minutes without wiring

Design Test

- Much faster than previous 3D electronic design methods
- Just a little bit slower than PCB design
- Accurate positioning hard because of missing gird
- Rotation is not very handy
- Identification of connected components is not easy
- 3D display gets a little bit slow with many components

Placement Test

- Tests the correct generation of placement informations
- Printing a real test device with a 3D electronics printer
- Wiring was designed with a 3D CAD software



Limitations

- Slicing tool is not exchangeable
- Methods that depend on different tools cant be used
- Wiring is not implemented yet
- Some features are missing
- Identification of the pins of symmetrical parts is nearly impossible

Conclusion

- Possible to design real 3D circuits with lower effort
- Test showed that the designs are printable
- Whole implementation is available as open source software

Outlook

- 3D printed electronics can be part of next industrial revolution
- Maybe possible to print new products with integrated electronics or reduced size
- Can reduce the costs for prototypes or small series
- Software has to be developed much further
- Missing features has to be implemented
- Software process has to be addressed by more researchers

Bibliography I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