IDETC/CIE 2013
ASME 2013 INTERNATIONAL DESIGN ENGINEERING TECHNICAL CONFERENCES and COMPUTERS AND INFORMATION IN ENGINEERING CONFERENCE
AUGUST 4-7, 2013 • PORTLAND, OREGON

Graph based automatic selective disassembly time computation and product architecture redesign suggestion
CIE 2013 Graduate Research Poster

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Introduction

Four major processing options at the end-of-life of products are: reuse, recycle, remanufacture and disposal.

- In order for a product to be recycled or remanufactured, the product is disassembled and various components are sorted.
- For recycling and remanufacturing to be cost effective, one important factor is disassembly time [1-3].
- Selective disassembly is helpful in saving cost and time when manufacturers want to remove some specific parts from retired products [4-6]

Objectives

- Develop automated tools to estimate disassembly time for a given CAD assembly model and to provide design guidelines to reduce disassembly time.

Methodology

- Disassembly is assumed to be inverse of assembly.
- Use assembly time estimation developed by Summers et. al, [1], for estimating total disassembly time.

$$t_d = (APL \times n^{1.188+PLD}) \quad \ldots\ldots(1)$$

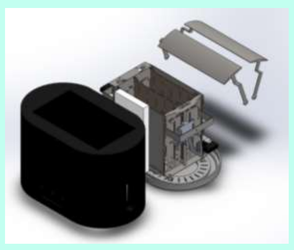
where, *APL* is average path length, *PLD* is path length density, *n* is the number of relationships in the graph and t_d is the estimated time

- Utilize assembly graphs from the CAD model to obtain connective complexity metrics. Based on user selection to group assembly graphs to obtain selective connective complexity metrics.
- Compute disassembly time using the connective complexity metrics through equation(1), whose reliability is 85% according to result of refinement on 9 cases in [7].

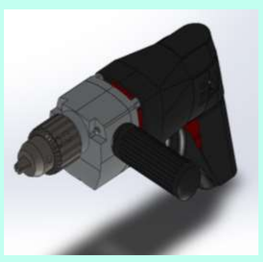
Case Study:

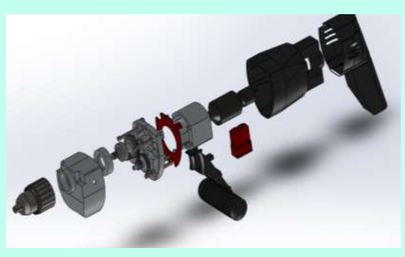
- Standard Toaster (Oster Toaster Model# 6325).

- Eco Toaster (TE-249)



- Drill (grabcat.com)





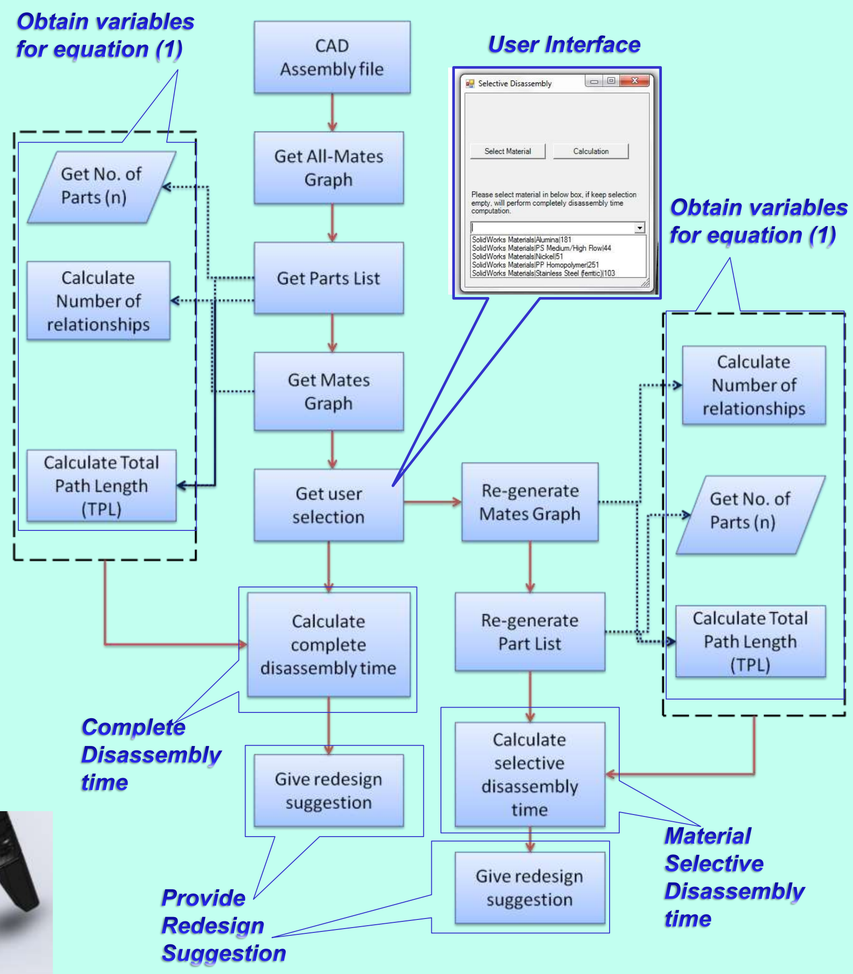
Abstract

Base on the report from U.S. Environmental Protection Agency (EPA), in 2010, Americans generated about 250 million tons of trash. Among the total amount, durable goods, such as furniture, home appliances, consumer electronics, etc., make up the third largest segment, accounting for about 49 million tons, but the recovery rate only 18.5%. Most of the generated solid wastes are disposed of by landfill and combustion. A proper method recommended by EPA to increase the recovery rate is manufacturers take back products on their End-Of-Life (EOL) stage. However, only 10% to 20% of the recycling expense depends on recycling process optimization, the rest is already determined at the product design stage[8].

The goal of this research is to develop automated tools to estimate disassembly time and suggest changes in the product in order to reduce the disassembly time. The methodology utilized to estimate disassembly time is based on metrics from assembly graph and is also based on the assumption that disassembly is inverse process of assembly. Solid Works Application Programming Interface (API) and C# is chosen as the language to demonstrate the tool and algorithms.

Keywords: Disassembly time estimation, redesign suggestions, disassembly time reduction, assembly graph

Program Algorithm



Results

- Standard Toaster

	Part Number	t_d/s	t_d reduction %
Complete Disassembly	36	234	base line
Steel	16	64	73%
Polypropylene	35	227	3%

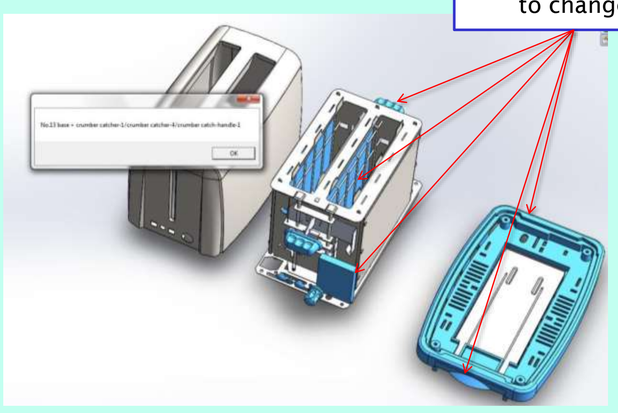
- Eco-Toaster

	Part Number	t_d/s	t_d reduction %
Complete Disassembly	42	282	base line
Steel	10	37	87%
Polystyrene	41	274	3%

- Drill

	Part Number	t_d/s	t_d reduction %
Complete Disassembly	24	150	base line
Aluminum	23	143	5%
1060 alloy	18	111	26%
ABS	22	86	43%

- Redesign Suggestion Example (Standard Toaster, Steel)



Conclusion

- Program developed in this research is able to automatically estimate material selective and complete disassembly time for three given CAD assembly models
- Reduction in the estimated disassembly time for material selective disassembly than complete disassembly.
- Material selective disassembly time vary according to user material selection.

Future Work

- Estimate Multi-selection disassembly time
- Develop equations to estimate destructive disassembly time
- More realistic assumption for disassembly time estimation

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