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APPLICATION OF MODERN APPROACHES IN DISASSEMBLY

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ABSTRACT
Economical and environmental indicators directed the development of electronic waste disposal to the process of recycling which means the extracting and reusing of the waste materials. The main economic driving force for the recycling of electronic waste is the recovery of precious metals and other materials such as plastic and glass. The large quantities of e-waste being generated have spawned a new industry: e-waste recycling. E-waste recycling is lucrative business because electronics consist of valuable materials such as gold, copper but also plastic, glass, etc.
Electrical and electronic equipment are made up of a multitude of components which contain toxic substances, e.g. carcinogens such as lead and arsenic, which form a serious health risk and environment danger. Dismantling of electronic devices is very difficult and needs to use huge ratio of human factor. The solution how to simplify dismantling is new design of electronic devices.
This article deals with application of modern approaches in disassembly and their application in recycling
Keywords: e-waste, dismantling, recycling

1. INTRODUCTION
Waste is a major problem in modern society. The common practice of disposing waste in landfills is increasingly discouraged in industrialized countries because of the risk of hazardous substances causing harm to the environment for example, leaching of toxins from the waste could contaminate ground water.
In the recent year, end-of-life disassembly has gained popularity because of both economic incentives and growing environmental concerns. Industrial ecology represents a firmly established systematic and integrated philosophy for dealing with the environmental aspects of the economy. The goal of industrial ecology is to promote sustainable development and affect a fundamental paradigm shift in thinking concerning the relationship between industry and ecology by efficient use of resources and by closing the loop of materials and energy flows in an effort to reduce their impact on the environment.
This paper describes disassembly process as one of the most important systematic approach and methos of disassembly proces, which are used for optimalizing disassembly time and cost.

2. ANALYSIS OF THE DISASSEMBLY PROCESS

Disassembly is defined as a systematic approach to separate a product into its constituent parts, components, subassemblies or other groupings. In the manufacturing approaches over the past few years, disassembly has been a key issue.

Disassembly plays a major role in recycling of products for being more environmentally friendly. Environmental consciousness has become increasingly important for both product manufacturers and consumers. Product disposal costs have also triggered customer pressure for more environmentally safe products. Waste recycling has been an active approach in achieving this and therefore disassembly becomes essential in almost any industry.

Disassembly sequences are also required for service purposes, i.e. for maintenance and component replacement. Another significant area of interest in the disassembly sequencing is for identifying possible assembly sequences since disassembly sequencing can be considered as a reverse procedure of assembly sequencing [1,5].

It is apparent that disassembly is an essential area of research and is beneficial for both the manufacturing industry and our environment. In the past few years much progress has been made and several disassembly techniques have been identified:

a. Manual and automated disassembly
b. Partial, selective and complete disassembly
c. Parallel and sequential disassembly
d. Non-destructive and destructive disassembly

2.1. Disassembly Sequence Planning

One of the main tasks in disassembly process planning is to determine the best disassembly sequence. Disassembly process planning is critical in minimizing the amount of resources (time and money) invested in disassembly and maximizing the level of automation of the disassembly process and the quality of parts recovered [1,3].

Disassembly sequence planning determines the best order for separating a product into its constituent parts, components or other groupings. It aims to find all possible disassembly sequences and finally an optimal sequence. The research involves non-destructive disassembly and therefore must remove a part without interference with other parts.

In recent years many different methods were proposed for optimal disassembly sequencing [1,5].

2.1.1. Graph-based approaches

Graph theory has been a powerful tool to solve disassembly sequence generation [4].

**AND/OR graphs* can generate all feasible operations for the disassembly of a product and provides a search basis among alternative disassembly plans.

**Cluster graph* is built by classifying the components in the assembly into different levels based on their accessibilities.

**Interference graph* for identifying interference in disassembly. The interference graph is created from an interference matrix, which is a square matrix A of order n where n is the number of components in the product.

**The connectivity graph* is modeled as a matrix C of size n x m where n is the number of components and m is the number of connections made by the components with each other in the product.

**Disassembly hierarchical tree* designed to model the 'Onion peeling' abstraction which recursively disassembles removable components starting from the boundary and proceeding inwards.

2.1.2 Geometry based approaches

Geometric theory has been used as a mathematical tool for disassembly sequence analysis recently. Srinivasan [6] proposed a "wave propagation approach" to reduce the complexity for optimal selective disassembly sequence generation. Generating 'disassembly waves' to arrange components in topographical forms and analyzing the priorities of the intersection events between the disassembly waves was proposed to determine the optimal disassembly sequence. Lee proposed a nondestructive disassembly (N-DD) and a destructive disassembly (DD) approach to disassemble a component. The

N-DD approach utilizes a direction-based method to disassemble components with an inherent assumption that only a single and linear translation disassembly motion is being used. One component is removed at a time and the remaining assembly is treated as one object. This process is repeated until all the components are disassembled. If there is still an assembly remaining, DD is applied that cuts off along the interactive surfaces between the two components [2].

2.2. Application of hierarchical tree structure approach

Several report on disassembly processes in the literature are devoted to the estimation of time and cost. In most of these cases, a predefined disassembly sequence, arranged as a hierarchical structure, which is similar to the bill of materials, is assumed. The registered time was subdivided into handling time and disassembly time. Further suggestions were made on the operators need for additional information and on the need for specialized tools [1,5].
Typically, the hierarchical tree representation has a modular structure. This implies that parallel disassembly is permitted and at the time may even be essential, in such a model, which results in a divergent structure. The disassembly sequence for obtaining a specific component is fixed in such a tree. Additional information on the composition and mass of the components may be essential.
As an example of this approach, some steps for disassembling a printer are depicted in Figure 1.

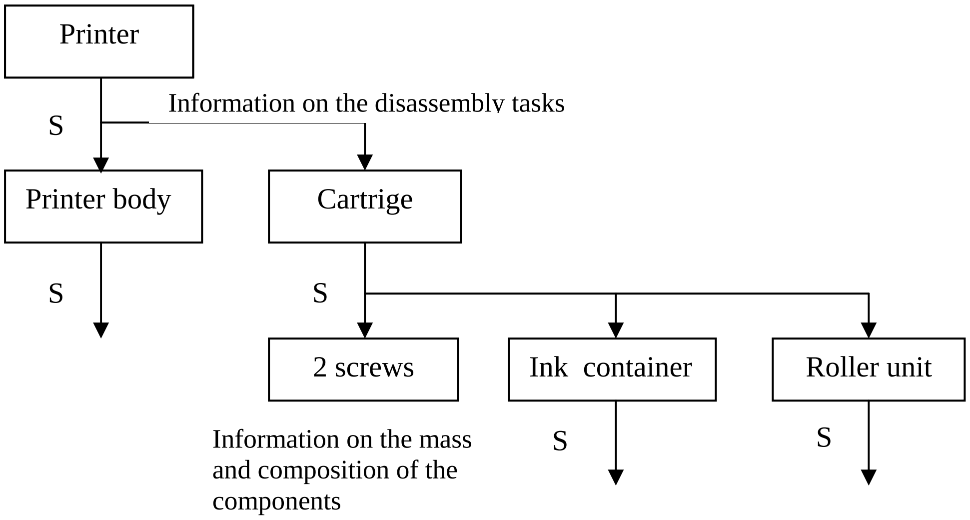

Figure 1. Part of hierarchical tree structure in disassembly study of printer (the symbol S refers to a subassembly; it is absent in case of singe product)

The hierarchical tree structure is only appropriate for a product that has a distinct modular structure. If there is a demand for a particular component, the tee structure offers a unique way to get it. For example, to retrieve the “main PWB”, the following sequence of disassembly operations is necessary:

- Detachment of the cover
- Detachment of the CRT unit
- Detachment of the screen module
- Detachment of the cable entry
- Detachment of the data cable
- Detachment of the main PWB

A thorough analysis of disassembly processes by subdividing them into operation and tasks is the basis for sound cost metrics.

3. CONCLUSION

Disassembly has achieved significant attention in the past few years for its pivotal role in waste recycling, remanufacturing and servicing of components for maintenance. With more emphasis on products to be environmentally safe, today, the need for efficient and cost effective disassembly process has gained momentum. The thesis studies the current approaches in sub-assembly detection, disassembly sequencing and path planning and proposes methodologies that tend to better approach disassembly processes applicable to any manufacturing industry.

Evaluating the disassembly of parts at the design stage to minimize the cost and time spent in removing target components in selective disassembly is another area of research.

This research aims at three main disassembly procedures involved in achieving faster and efficient methods of disassembly than the current practices.

One of the main tasks in disassembly process planning is to determine the best disassembly sequence. The disassembly sequence generation determines the best possible order for separating a product into its constituent parts.

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