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Vision-based Identification Service for Remanufacturing Sorting

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Abstract

One of the main goals of sustainability is to reduce the ecological footprint. As a result the automotive industry has been encouraged to become more efficient in using existing resources to reach a target value of at least of 85 % of a car's weight for reuse and recycling as of 2015. The trade of used parts is expanding in total amount as well as in diversity of items. In industry practice employees have to decide upon the further use of a product based on experience or a reference list. We introduce a machine vision-based service for the identification of exchange parts. Images and weights of used parts serve as input whereby extracted inherent object features determine the identification of respective parts. First, in two main steps data is pre-filtered by its dimensions and volume out of a low-level 3D-model, created by a Shape-From-Silhouette algorithm. Secondly, a feature-based matching process is performed on the images. Two different feature matching approaches, a classic key point-based as well as a convolutional neural network, are evaluated. First results show the proof of concept recognition rates up to 96 %.

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Keywords: Remanufacuring; Sorting; Machine Vision; Core Management; Identification; Object Recognition; Reverse Logistics; Closed-Loop Supply Chain; Inherent Features

1. Introduction

Remanufacturing has become an essential process for manufacturers of multiple industries. Since raw materials are only available in finite supply and extracting them may be cumbersome and costly, manufacturers have an incentive

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to reuse materials and parts. Remanufacturing as opposed to recycling does not break down a part back into raw materials, but reuses the part without major changes. Furthermore, manufacturers have the obligation to follow a sustainable production chain as defined by the United Nations Development Programme's Sustainable Development Goal 12: Responsible Consumption and Production, which targets global sustainable use of natural resources by 2030 [1]. By directive 2000/53/EC automotive sector manufacturers are required to factor into the design of their parts a reusable or recyclable portion of at least 85 % of its weight [2]. This motivates a circular economy, which is regenerative and restorative by design and aims to keep parts at their highest utility and value, thus closing the loop on a linear economy ("take - make - dispose") [3]. Remanufacturing can be seen as a "win-win-win" approach: the customer pays less for remanufactured parts compared to new parts, the manufacturer is able to earn more, by not producing the cores from scratch, and more importantly it is a sustainable solution [4]. In the context of the automotive sector, the following definitions for a core and the remanufacturing process were used, as defined by an alliance of global automotive associations:

"A core is a previously sold, worn or non-functional product or part, intended for the remanufacturing process. Remanufacturing is a standardized industrial process by which cores are returned to same-as-new, or better, condition and performance." [5]

We denote a car workshop or similar as "the customer". Due to some parts not being remanufacturable (e.g. safety critical parts, defective parts, cost factors, etc.), an important decision to be made when receiving a part for possible remanufacturing is identifying the part and sorting it based on its specific routing criteria. Since the quality and condition of incoming cores determine the profitability of a remanufacturer, by requiring the remanufacturer to perform 100 % inspection of the accepted cores, it is beneficial to invest in core sorting [6] [7] [8]. When a core is identified it may need to be inspected further for defects, which may exclude it from the remanufacturing process. Currently, core sorting in the automotive sector is still mostly a slow and manual process which hopes for improvement through an automated process. Our system tries to solve this problem by means of an automated visual inspection approach.

1.1. Problem Description

In the remanufacturing closed-loop supply chain there are three major steps before the actual remanufacturing process is performed. These will be illustrated in an automotive application (Fig. 1):

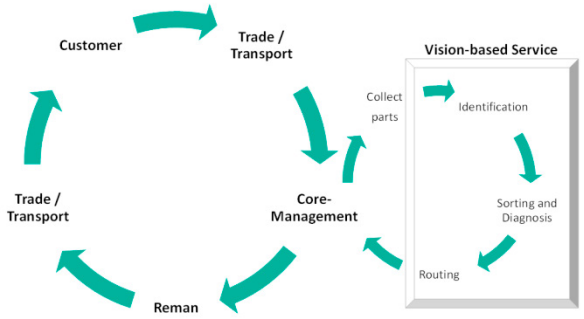

Fig. 1 Example for a remanufactured part's Life Cycle Management

Firstly, a customer orders a new or remanufactured part, e.g. a turbocharger. The removed exchange part is secondly collected by a reverse logistics service provider. It is then transferred to a warehouse where the incoming goods have to be sorted for further use of remanufacturing, recycling or environmentally appropriate disposal. From our experience with a leading automobile manufacturer the core management is likely to be outsourced to service providers. These handle the collection and sorting of cores following the instructions provided by their clients. The