An Ontology based Context Aware System to Control the Robot Manipulator in Delivery Logistics Industry

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Abstract. Due to the sensational success of the Internet market, the use of parcels becomes increasing every year. Therefore, it is necessary that the traditional method of sorting parcels in local delivery center, which has been manually done, should be replaced with automatic smart robot manipulators. In this paper, we propose an ontology-based context aware system for generating information to control the movement of a robot. The context aware service in logistics industry generates intelligent information to control a robot using context data such as the parcel shape, weight, location and barcodes, and processes automated sorting of parcels according to delivery persons and delivery routes. The proposed ontology based context aware system performs to collect contexts of the parcel and carries out reasoning of generating robot control data to pick up and drop parcels according to contexts. It will help save much time and cost by automating parcel delivery sorting process, so that it will contribute to reduce the frequency of industrial accidents.

Keywords: Ontology, Context Awareness, Parcel Delivery, Automatic Sorting, Smart Robot Manipulator

1 Introduction

Because of the rapid development of e-commerce and mobile computing environment, the volume of logistics industry becomes increasing every year. The parcel sorting operation in current logistics industry is performed mechanically using an automated sorter installed at a large distribution center. However, delivery sorting process which classifies parcels by delivery orders is manually done by deliverers working at local delivery centers such as local post offices. The parcel delivery sorting operation, which is performed largely by hands, is made up of the initial sorting, where arrived parcels are sorted according to delivery persons, and the second sorting, where parcels are sorted according to the delivery order within delivery person's assigned area. Due to the volume and weight of parcels, the issues of excessive labor and industrial accidents related illnesses in muscular and skeletal systems can arise, which necessitate the improvements in work conditions by introducing automation which a robot manipulator is applied to. In many other
industries such as automobile and electronic industries, robot manipulators are widely used to conduct efficient products distribution. Unlike the existing robot manipulator which repeatedly conducts programmed work with standardized items, the new robot manipulator is able to recognize information about different size and weight of parcels and create pickup control information after receiving parcel information such as shapes of parcels or transport information. To do so, it is necessary to design and implement the context aware system which enables to collect context information of parcels and create robot controlling information accordingly. The rest of the paper is organized as follows. Section 2 describes the process of the automatic parcel delivery sorting and Section 3 presents the ontology-based context aware system for generating information to control robot in detail. Section 4 explains how the proposed system is working and we briefly conclude in Section 5.

2 Robot manipulator-based automatic sorting process for parcel delivery

General industrial robot manipulators only carry out pre-programmed work so that they cannot be used in more delicate work such as sorting parcels according to different size and weight. The current robot manipulators used in the distribution industry target at same-sized and same-shaped boxes or small pallets due to the technical limitation. In order to overcome existing problems, it is required to change control orders frequently according to the contexts given to robot manipulators by analyzing the context of parcels such as shape, weight and location.

In the smart robot system for automatic parcel sort, a system for creating control information is essential to enable robots to provide an active process. The figure 1 shows the smart robot model for logistics industry. Automatic process for context aware-based delivery sorting system goes through the following seven steps.

Step 1: This step includes processes of recognizing image, weight and location. Context information and barcode information sent by the barcode recognition sensor are collected in this step.

Step 2: Robot pick-up control information is created with algorithm using context information collected in the first step.

Step 3: More sophisticated robot pick-up control information is created and modified using the rule base.

Step 4: Delivery addresses of parcels are read by using barcode information collected in step 1. In this step, the delivery orders are decided by addresses.

Step 5: Robot manipulators are appointed according to the delivery orders of parcels. The delivery information is transferred to the conveyor.

Step 6: According to the delivery orders, locations of delivery sorting boxes are sent to robot manipulators.

Step 7: Conveyors and movement of robot manipulators are monitored and the results of delivery sorting process are analyzed.

In the process of step 1 to 3, context aware system is applied to create robot control information based on various parcel contexts.
For the context aware service, first we define the domain ontology and the context model. Then we construct rule base, which performs reasoning for generation of robot control data according to the context of each parcel.

The context acquisition module collects contexts from various sensors. We define domain ontology and construct an ontology based context model for a robot manipulator to perform sorting parcels automatically. The context knowledge base stores rules for context service. Sometimes the context data is invalid, so the context reasoning engine figures out the context data, and enables to generate revised contexts for proper context service. In section 3, we describe the details of our ontology based context aware system to generating information to control the robot manipulator for automatic sorting for parcel delivery.

3 Context Aware System for Automatic Sorting for Parcel Delivery

3.1 Ontology-based Context Aware System

The architecture of the context aware system, which performs context service and reasoning based on ontology, is shown in Figure 2. The raw data transferred from the sensor through the interface is stored in the context information DB going through the process of abstraction and generalization in the context collector. And the context manager, which provides robot control information, analyzes the context by managing and processing rules. Then it recognizes the context by relational database ontology. It also creates robot control information and transfers it to the robot utilizing knowledge base.
As shown in figure 3, the final robot control information is created through three-step rules. In the first step, the validation rules are used in order to validate context data of parcels and to decide initial data that is classified as an error. It is a very important step since context information coming from sensors often has errors. After applying the validation rule, the invalid information or the initialized information is restored. If there is no item applied to the validation rule, the next step will be the pick-up rule process, which creates robot control information.

The pickup rule creates the final robot control information. If the context information is not enough to be processed, the pickup rule cannot be applied. In this case, the context aware system will give a rejecting order to the robot, and parcels will be sent to an unclassified box. In order to generate robot control data, we need to get five coordinates: four from the angular points of the upper surface of a parcel and the center point as shown in figure 4. The four coordinates are numbered as 1 to 4 and center 5. And we can calculate three values such as alpha, beta and gamma, shown in figure 4. The robot needs to get the values such as alpha, beta, gamma and weight of parcel in order to pick up a parcel.
3.2 Experiments

The parcel context information, which is calculated by the four coordinates on the upper side of parcels, the central point, weight and barcode, is entered. The context aware system sent pickup information, such as alpha, beta, gamma and suction pressure to the robot control system. The context manager, which provides robot control information, analyzes the context through managing and processing rules, and recognizes the context through relational database-based ontology. Robot control information is also created by a reasoning engine based on knowledge base and sent to the robot.

As shown in the Table 1, the CASE 1 was the normal context data of the parcel sent from sensors. The robot control data was generated and the result of the reasoning of the CASE 1 is in the Table 2. Using this data the smart robot manipulator can pick up the parcel. In the CASE 2, CORDNATS1_X and CORDNATS1_Y were missed, so the context reasoning engine found out the values of CORDNATS1_X and CORDNATS1_Y. In this case the parcel was able to be picked up by the robot, which could receive pickup control data from the context aware system. The CASE 3 was shown that the values of CORDNATS2_X and CORDNATS2_Y were invalid due to the excessive difference of the two values. The context reasoning engine recognized the wrong values and applied revision rules. Then revised pickup control data was sent to the robot and automatic parcel sorting was successfully carried out.

<table>
<thead>
<tr>
<th>pick-up control data set</th>
<th>RESULT 1</th>
<th>RESULT 2</th>
<th>RESULT 3</th>
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<tbody>
<tr>
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<tr>
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<tr>
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<td>--</td>
<td>0</td>
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<td>Gamma</td>
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<tr>
<td>Pressure</td>
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</table>
4 Conclusion

In this paper, we proposed ontology-based context model to handle the robot manipulator to sort parcels and set the order of delivery automatically. We applied the concepts of ontology to context aware service. We defined domain ontology and designed class hierarchy for the logistics environment. Also we implemented relational database, which was mapped to the ontology of context aware system. The contribution of our work is to reduce time, cost and the frequency of industrial accidents. In the future works, the proposed context aware system can be installed with conveyors and machine systems, and it will be operated in post offices and delivery centers.

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