Transformation of System Action for Reconfigurable Automation Work System

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Abstract. The main idea of this paper is recent about the transformation of system actions extracted from the user requirement. The system actions are required before the implementation of reconfigurable automation work system. The systems chosen for this work includes basic sorting, assembly and painting process. The system actions are selected and specified base on suitability of each process. Later, each system actions are matched with suitable system components to create a set of system specification. This specification is used to implement the automation system for each process. Various automation components are used to achieve this work. This includes the use of Programmable Logic Controller (PLC) as the main controller. The developments of the systems are limited by some constraints such as number of component used as well as the availability of component in the repository system.

Introduction

Changes in user requirements and low flexibility of the system are amongst the challenges that limit the system's capability [1]. In order to encounter this issue, Reconfigurable Manufacturing Systems (RMS) has been introduced [2-4]. Prior to implementing the RMS, a system specification is required. An appropriate system specification is an essential step leading to the successful implementation of automation work system configuration. The system need to be configured and reconfigured accordingly from time to time in order to adapt with the new user requirements. The basic reconfiguration activity for this work is shown in the following Fig. 1.

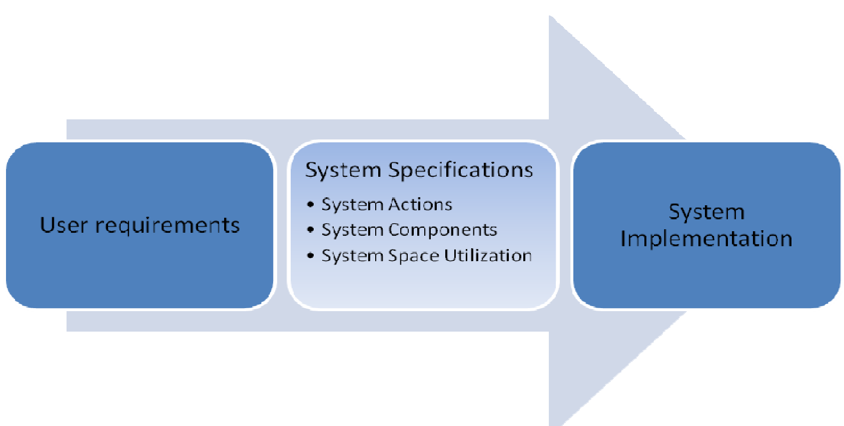


Fig. 1: Reconfiguration Process Activity

Currently, the way system design engineers reconfigure their automation work system is through a time consuming evaluation and costly redevelopment [5-7]. Introducing the more suitable method which allows the manufacturer to easily reconfigure with less time and investment is an immense step towards competitive manufacturing. In order to implement the new reconfiguration, system specifications need to be finalized. The system specifications consist of system actions, system components and system space utilization. In automation work system reconfiguration, engineer requires an understandable set of user requirements, either from verbal description or by some documentation [8]. The proposed model structure transforms a set of user requirement which usually comes together with the physical and/or non physical constraints. Since there are no defined working rules of integrating or matching user requirements with system constraints, the system design process is an intuitive and often unpredictable task.

In this paper, a general extraction of user requirement is shown in the next section. Later, the information on system specifications including selection of system action and system components are discussed. To conclude the work, an example on system implementation work for sorting process is shown in this paper.

User Requirements

At the beginning of the process, the platform/framework requires an understandable set of user requirements, either from verbal description or by some documentation/statement, to formulate a conceptual model of what the system is supposed to do. This user requirement may come before or after a system is already available. The goal is therefore not about adapting one system to another, but rather to develop a system design from user requirements independent of the platform, and subsequently carry out a matching process that assigns components to achieve the specified function. Examples of user requirements are illustrated in the following statement:

a. Sort 2 materials by weight
b. Assemble 2 parts by inserting B on top of A
c. Paint using 2 different colors on 2 different surfaces

From all the requirements, the extraction process begin with identifying the process type (P), item count (I) and condition (C) which at this stage known as an identifier. The following shows some possible component for each identifier.

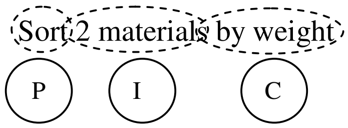
- Possible Process Type (P):
    - Sorting – 1, 2, 3, . . . , n product
    - Assembly – 1, 2, 3, . . . , n part
    - Painting – 1, 2, 3, . . . , n color

- Possible Number of Item Count (I):
    - ‘n’ number of product
    - ‘n’ number of part
    - ‘n’ number of color

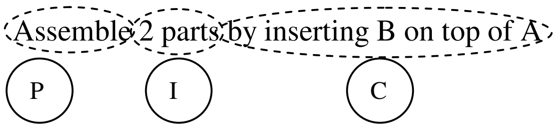
- Possible Condition (C):
    - By weight, material, height
    - From side, top, bottom
    - According to assignment

The following statement shows the extraction process for each of the user requirements:

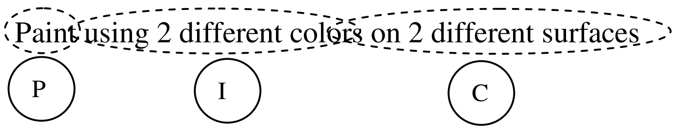
a.



b.



c.



System Specifications

In order for the development to take place, basic system specifications are required as a reference for developing the framework. These specifications are extracted from the user requirements provided at early stage of the reconfiguration process. In the next process, the extraction of the user requirements will eventually produce required system specifications.

System Actions and System Components

At this stage, list of componenst are required in order to suit with each system actions. Since the expected outcome of the manufacturing system may differ from one to another, extensive lists are required. The repository will provide heaps of data regarding various components required in the processing level of the proposed reconfiguration framework. It will be used once the steps and conditions are satisfied with the requirements. System action may consist of the following:

a. SORT
b. SENSE
c. TRANSFER
d. SLIDE
e. MEMORIZE

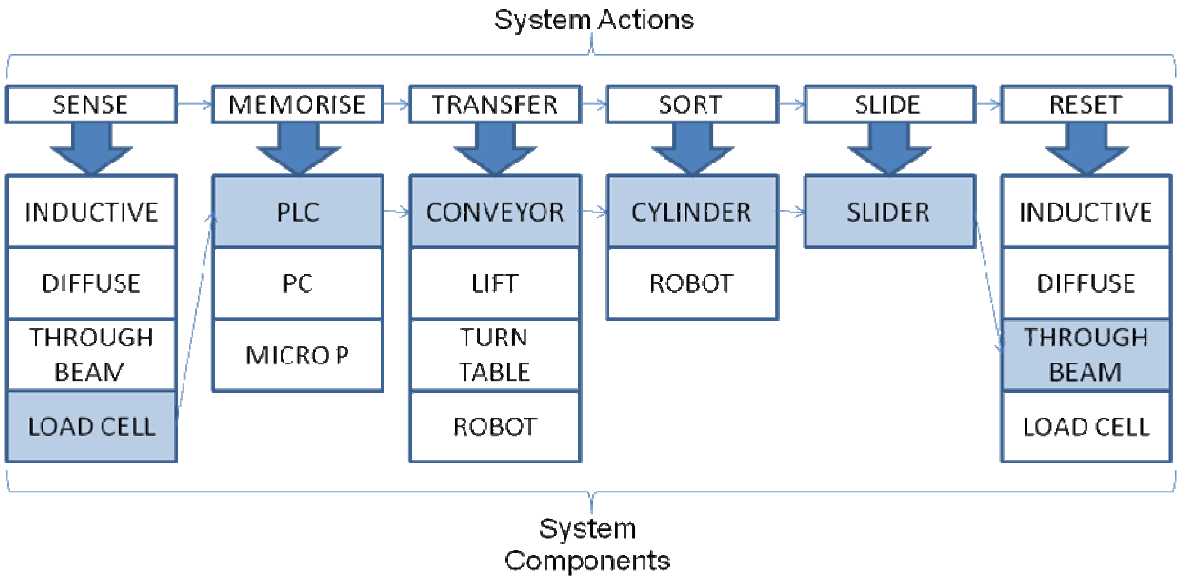
A set of components will be created which will store the database and will be known as system component repository. This repository contains numbers of components needed for setting up various types of system. Amongst the various components which will be kept in the library of component may consist of the following:

a. CYLINDER
b. SENSOR
c. CONVEYOR
d. SLIDER
e. PLC

System Actions and Components Selection

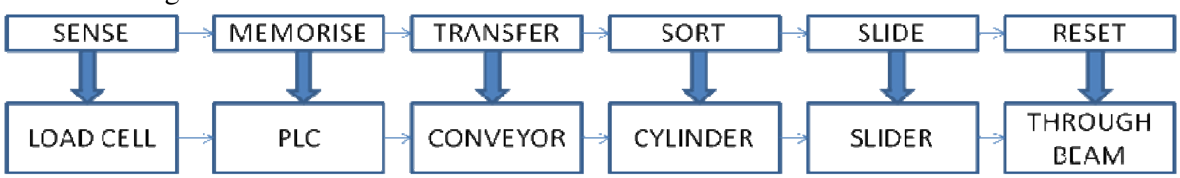
Selection/combination of the system action is based on the process type acquired from the user/system requirements. On the other hand, the selection of the system component is base on individual system action acquired in the prior stage. The following Table 1 shows an example of the selection of system components with corresponding system actions.

Table 1: Selection of System Components with Corresponding System Actions for Sorting Process

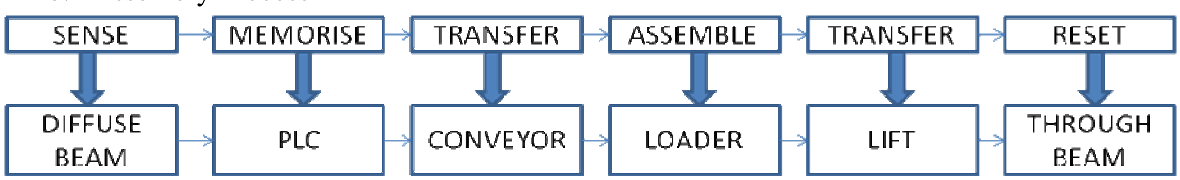


The following relationships shows examples combination of system actions together with system components for all three processes:

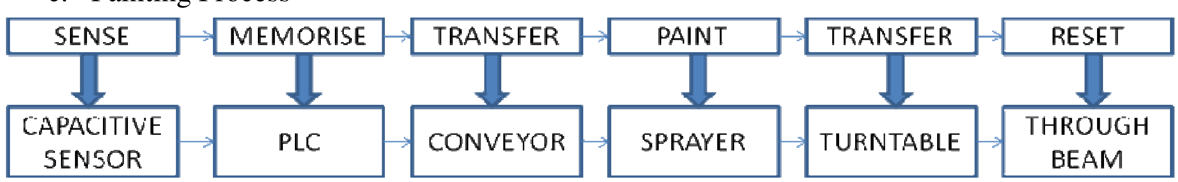
a. Sorting Process



b. Assembly Process



c. Painting Process



System Space Utilization

The first steps towards the implementation stages are to finalize the system actions and system components selection from the database. Once the components are selected, the approximate size of the system can be obtained for initial prediction of the space required for lying down the system. The following Table 2 shows the relationship to select the suitable components for each the actions.

Table 2: Components Selection for the Reconfigured Sorting Process

ACTIONS	COMPONENTS	QUANTITY	SPACE

			REQUIRED
SENSE	LOAD CELL	1	A_1
	THROUGH BEAM	1	A_2
MEMORIZE	PLC	1	A_3
TRANSFER	CONVEYOR	1	A_4
SORT	CYLINDER	1	A_5
SLIDE	SLIDER	2	A_6

On top of the listed components, accessories to run the system may be required but not included in this discussion. From the individual space information, the total required space for the complete system can be calculated as follow:

System Space required = $A_{system} = \sum A_i = A_1 + A_2 + A_3 + A_4 + A_5 + A_6$

The system space layout for the reconfigured sorting system in this work is shown in Fig. 2.

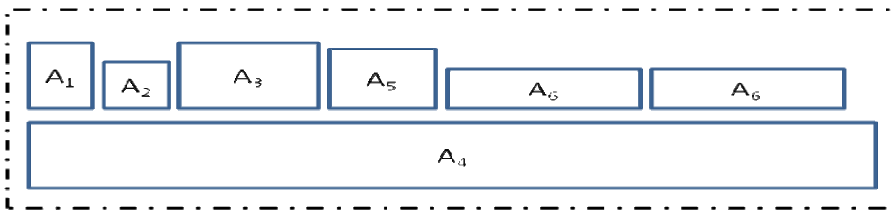


Fig. 2: Space Approximation for the Reconfigured Sorting System

The layout is not a final layout but is more on the sizing of the proposed new reconfigured system. At this stage it does not indicate specific orientation of the system. However the information is useful during layout orientation stage.

System Implementation

The initiation of the system implementation has been taken place using the modular automation system to show the preliminary outcome. The implementation has been developed in a form of system which is shown in Fig. 3. The system has been developed using the user requirements for sorting process in the earlier work section.

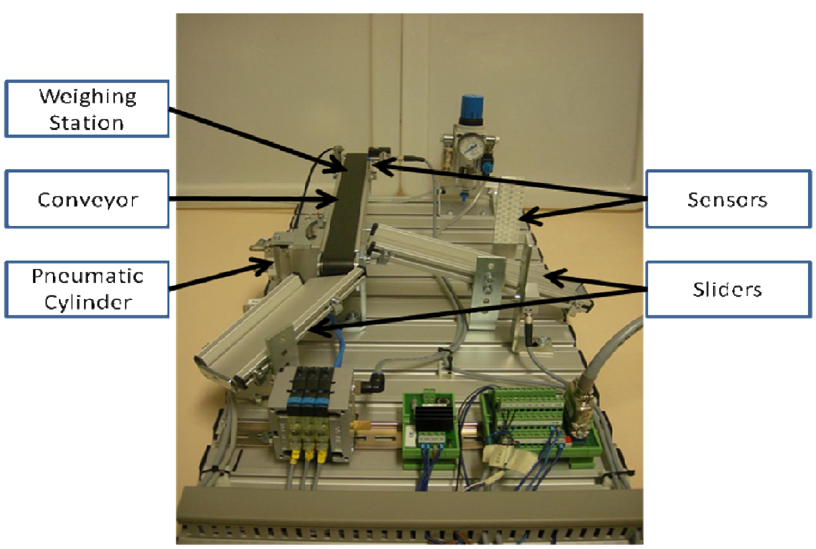


Fig. 3: Hardware Representation of the System Implementation

The system operates using conveyor as the transfer system. Once the product is placed on the weighing station, the conveyor will transfer the product from the current spot until it reaches the decision area. At the decision area, the pneumatic cylinder will either push the product onto the first slider or let the product through to the second slider. This decision making process is done by the Programmable Logic Controller (PLC). The implemented system has proved that the outcome of this work can provide a set of understandable system specifications for reconfiguration of manufacturing automation system accordingly.

Summary

In this paper the transformation of system actions for the implementation of a laboratory scale automation system for a given set of user requirements and system specifications are described. This work is part of the main reconfiguration structure for reconfigurable automation work system. The succession of this part will reduce the cost and time involve in redesigning and reconfiguring the manufacturing automation system. The end structure will later provide system specifications for the design of flexible and reconfigurable manufacturing automation system in total. In conjunction with this research work, the future expected outcome for the reconfiguration structure will be in the form of system coordination or layout.

Acknowledgements

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