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The development of database and HCI system for automated guided vehicle in web-based monitoring environment

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Abstract. Rapid technology development has in fact affected the industrial sector significantly. This is shown by the increasing use of automatic devices such as industrial robots and some automatic machines to run the production line. One of machines frequently used in production line is the Automatic Guided Vehicle (AGV), which is a mobile robot controlled by a computer to move above a previously defined guide lines. An AGV can move from one work station to another by following one direction guide lines. To have a good control on products involved in the production process, a database system needs to be developed to record the data related to product and production activities. Another requirement is the ability to monitor the movement of the AGV within the working environment. Besides, the number of products coming in to and out from one station have to be accurately recorded. Remote monitoring of the running process is now becoming a new requirement. The system can be monitored when a Human Computer Interface (HCI) is provided. This interface is designed in a web bases system so that some personal in charged with a certain privileges can access the monitoring system from a distance. They can just monitor or even give command to the system when necessary.

When the system runs, the AGV continuously reports its position to the main controller and the product they bring as well. AGV and product identification are done by using a bar code reading system. In controlling AGV, a proper database system is required as a part or the whole data can be utilized by the user. One of the data model that can be used is relational data model. Database development using relational data model is done by collecting all desired data. Afterwards, from these data entities, attributes and primary keys have to be defined as well as the relationship between entities. The relationships can be clearly seen in the Entity Relationship Diagram (ERD). This diagram is then normalized and the result will become a ready to use database. This work results in a database for controlling and monitoring an AGV that embedded to a web based monitoring system

Keywords: automated guided vehicle, data flow diagram, entity relationship diagram, physical database, human-computer interface.

1. Introduction

In the last three decades, a rapid technology development has in fact affected the industrial sector significantly. The main development happens in computer technology and this opens a higher possibility to use automatic machines in real life. This is shown by the increasing use of automatic devices such as industrial robots and some automatic machines to run the production activities. One of machines frequently used in production line is the Automatic Guided Vehicle (AGV), which is a mobile robot controlled by a computer to move along a previously defined guide lines. An AGV can move from one work station to another by following one direction guide lines (Premi, 1983). To have a good control on products involved in the production process, a database system needs to be developed to record all data related to product and production activities. Another requirement is the ability to monitor the movement of the AGV within the working environment. Besides, the number of products coming in to and out from one station have to be accurately recorded. In controlling the AGV movement, there are a lot of data needed when a feedback is coming from their environment or when a command has to be executed. All of these data are collected in a structural media that obviously called a database.

Technology development makes a borderless world that people can communicate easily from one place

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to another. People can now easily connect using internet facility. AGV monitoring and controlling embedded in an internet facility will give a new way of AGV control system, a kind of web-based system. In this system a user can monitor and input a command from any room. These actions to an AGV will be done better if it can be done not only from one place. Feature developed here will make those processes more easily. The system can receive any information from the AGV and work stations, and then it saves the information in an appropriate database as well can be shown in a web monitor.

Web-based AGV controller facility is an interface created as a media where people can interact with the computer when they are using the facility. Computer network is used in order to control and to give command to an AGV from several computers at the same time. The facility acts as human-computer interface and it must be designed to be user friendly, so that the users will feel the easiness and comfortable in using the controller facility. This research proposes a user friendly interface by applying the eight golden rules of making interface and paying attention in six criteria of a user friendly interface.

2. System Definition

As a material handling device, AGV is commanded to move from one location to another location for taking or bringing products that are processed in a production line. The simulated tasks are moving pallet loaded with products from or to the storage as well as to the work stations. The model of AGV and the production line is depicted in Fig. 1. The positions of the AGV are tracked (monitored) by the activation of the barcode at certain locations. In the simulation, activation is still carried out manually.

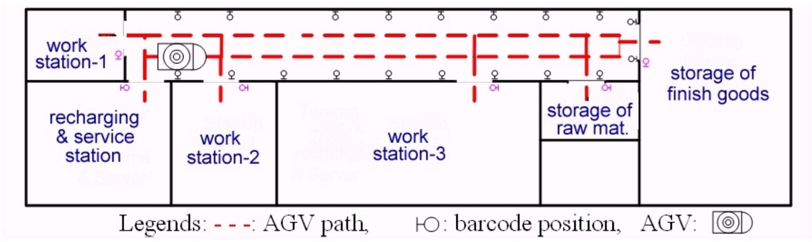


Fig. 1: Layout of AGV guide lines, origin and some destination places.

2.1. Types of AGV Activities

CSome specific activities may be performed when executing a command from the main controller. As a consequence, some data should be prepared and managed to monitor the following:

- Before starting and after executing one task, AGV is available at the base point (recharging station).
- AGV receives input command from computers at the base point or the work stations.
- AGV moves to station where the products/pallets are stored/ready.
- AGV takes the product/pallet at origin station.
- AGV brings the product/pallet to destination station.
- AGV stores the product/pallet at destination station.
- AGV will split command of multiple tasks into some single commands.
- During motion, AGV positions are monitored by sensors located along the guide lines.
- No power will run out as they are checked before assigning AGV for a certain task.

2.2. System Model Development using DFD

DFD is a network represents a computerized/automated system that consists of a set of components in which the flow of data from external entities into the system can be clearly seen as well as how the data moved from one process to another, and its logical storage (Scott, 2008, Sutabri, 2004). The stages in developing the DFD can be classified into 3 main parts, i.e.:

- Generation of context diagram, in order to illustrate the system in general.
- Generation of level 0 diagram, in order to visualize process stages in the context diagram.
- Generation of detail diagram (level 1, 2 and further), in order to determine the data flow in more detail then the stages in level 0 diagram.

In the first stage, we define the controlling facility system for the AGV. Afterwards, all related elements are defined such as the users, AGV, position sensors, and counter at each work station. The next stage defines the level 0 data flow diagram to see in more detail all activities in this facility as depicted in Fig. 2 (a) and (b), Fig. 3 and Fig. 4 depict the detail diagram of every process shown in level 0 DFD.

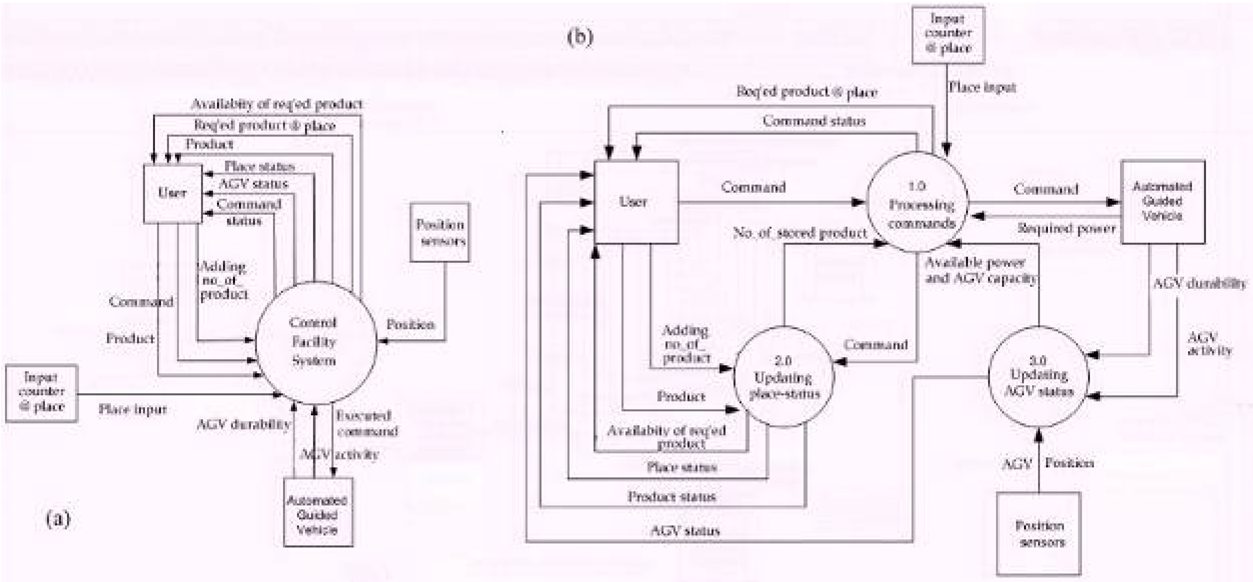


Fig. 2: (a) Context diagram of the AGV controlling facility, (b) the level 0 data flow diagram.

2.3. Important Information

Data model used in this work is ERD (*Entity Relationship Diagram*) data model as it can help organizing data in a project into some entities and determining the relationship among entities. Besides, ERD also results a good structural data base so that it can be stored and accessed efficiently.

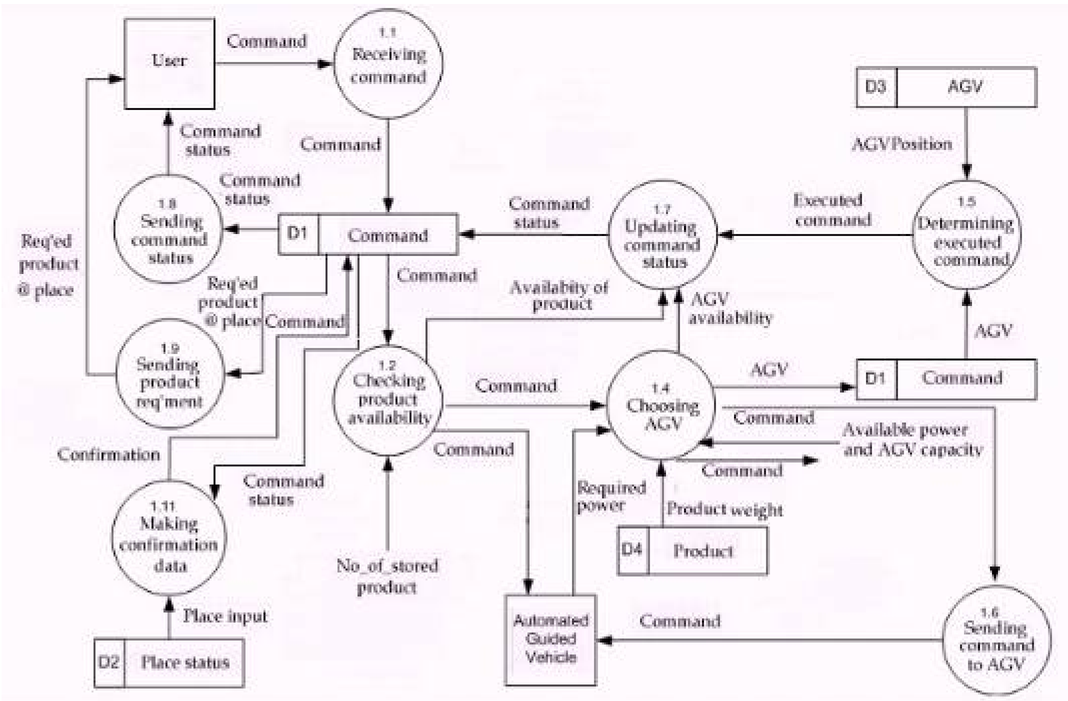


Fig. 3: The level 1of DFD of processing command (process 1.0).

The stages for defining ERD are as follows (Simarmata, 2006):

- Defining entity.
- Defining relation.
- Drawing the temporary ERD.

- Defining cardinality (relationship among entities).
- Finding the primary key.
- Drawing the ERD based on the primary key.
- Defining the attribute.
- Plotting the attribute.
- Drawing the final ERD.

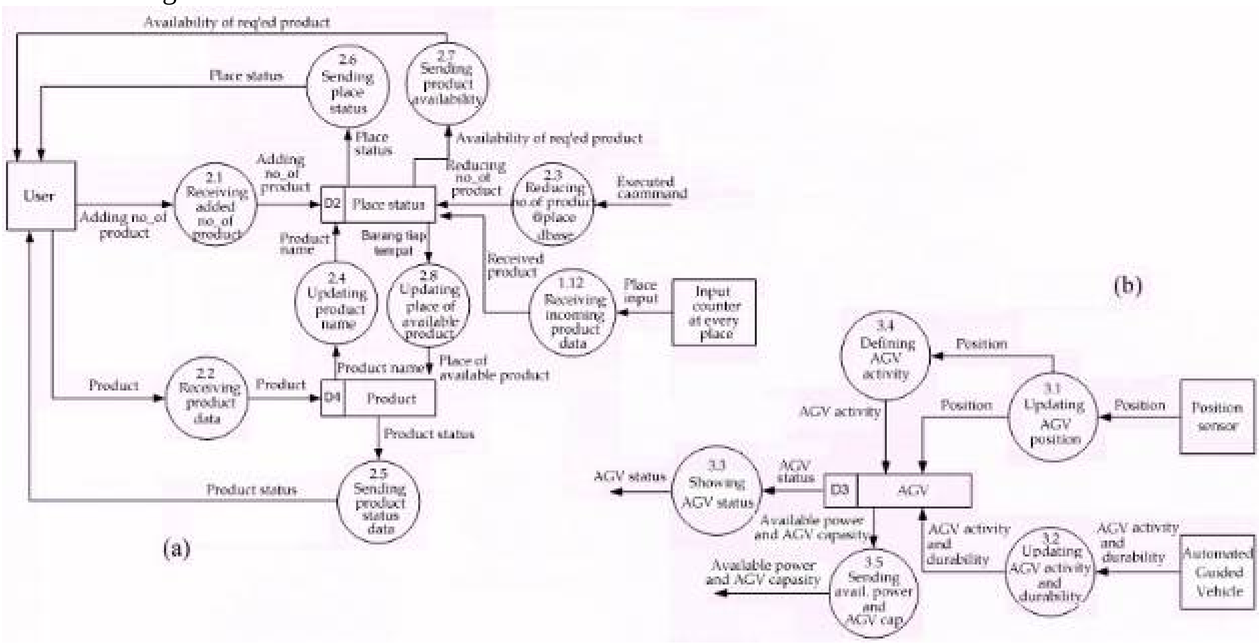


Fig. 4: (a) The level 1 of updating place status (process 2.0), (b) the level 1 of updating AGV status (process 3.0).

After performing the above mentioned stages then the following ERD is obtained as shown in Fig. 5. In this diagram, all entities are clearly seen as well as the relationships, the primary key and the attribute of each entity.

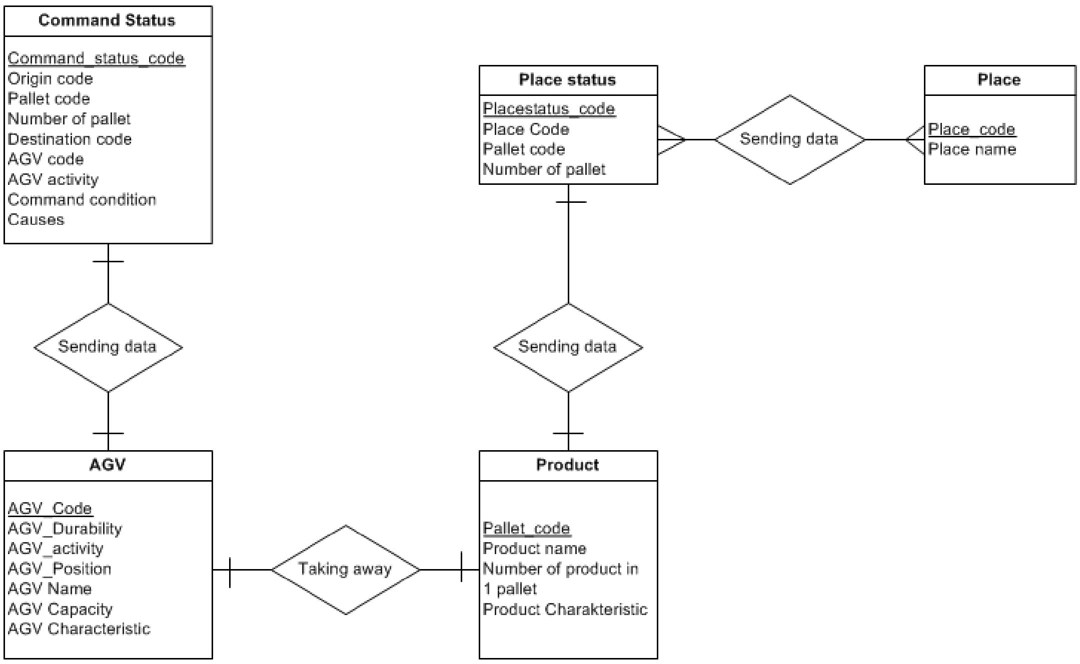


Fig. 5: Entity relationship diagram of AGV controlling facility.

2.4. Normalization and Design of ERD Data Model

A complex data structures are decomposed into a flat files called relations and this is done by normalization. This is because ERD data model can help organizing data in a project into some entities and determining the relationship among entities. Besides, ERD also results a good structural data base so that it can be stored and accessed efficiently.

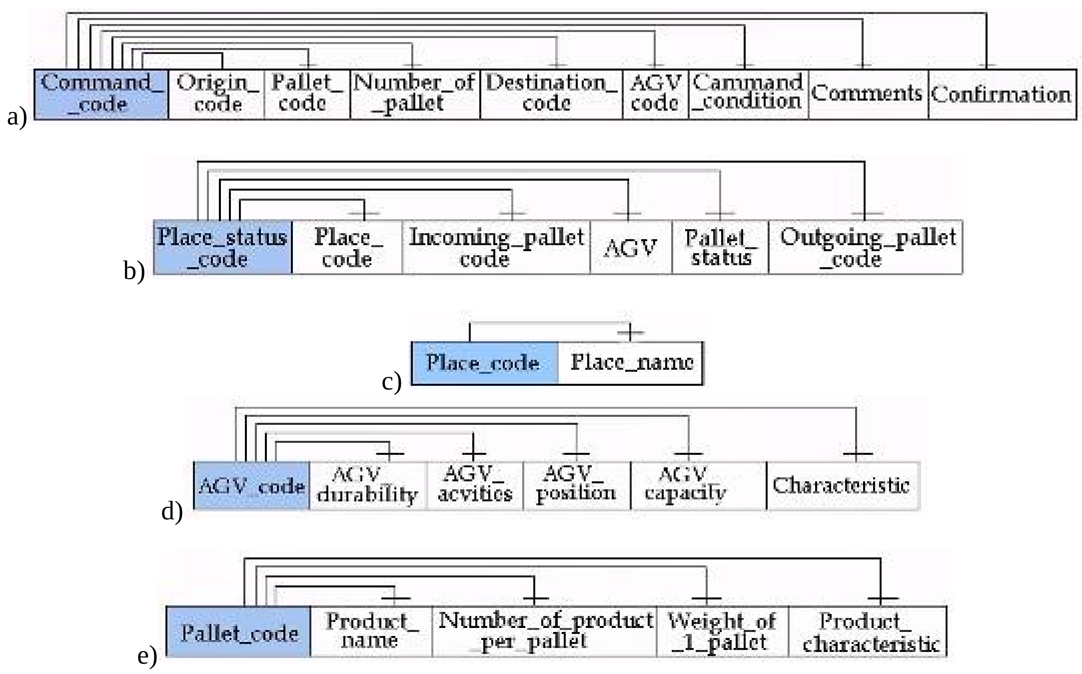
Three levels of normalization for generating an ERD are as follows (FitzGerald, 1987):

- First normal form (1NF) is a data structure without internal repeating groups. The first normal form shows all relations where only single value of attribute in the table (Nugroho, 2004). For instance, the place name of "raw material storage' shows only a single value.
- Second normal form (2NF)is a data structure in which all non-key data elements are fully functionally dependent on the primary key.
- Third normal form (3NF) is a data structure in which the following two conditions are met: all non-keys are fully dependent on primary key and no non-keys are fully dependent on other non-key in the system.

As the data available in the third level are normal in this experiment, so no further step needs to be done. The following is an example of relational table of data base obtained after executing the three level of normalization (Table 1). The data base is developed using MySQL application soft ware. There are five tables created in order to record all activities of the AGV and other elements related to it, such as:

- Command table, containing command code, origin code, pallet code, number of pallet, destination code, AGV code and activity, command status and causes of problems. In this table, type and size of the data elements should be defined as well as the nullity.
- Place status table, containing place_status_code, place_code, incoming_pallet_code, AGV_code, pallet_status, outgoing_pallet_code.
- Place table, containing place_code, and place_name.
- AGV table, containing AGV_code, AGV_durability, AGV_activity, AGV_position, AGV_capacity, AGV_characteristic.
- Product/pallet table, containing pallet_code, product_name, number_of_product_1_pallet, weight_1_pallet, product_charateristic.

Table 1: List of table after performing three levels of normalisation.



3. Experimental Results

(a) (b) (c) (d)

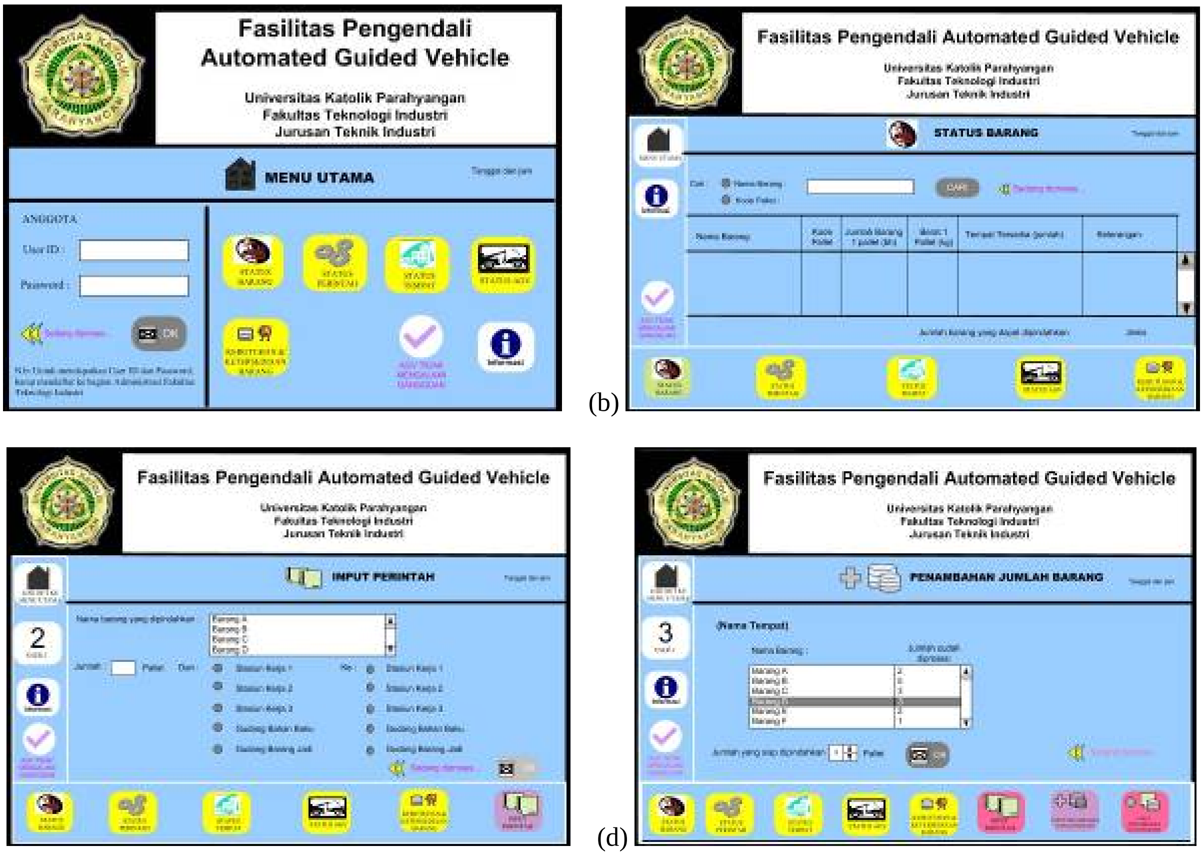


Fig. 6: (a) AGV controlling facility main menu, (b) AGV on the experimental setup (shop floor model).

Some simple experiments have been carried out to show the ability of the system to be run simultaneously by several users from different places (computers). The experiment set-up is realized on a template representing some work stations, bar coded position sensors and an AGV moving around associating with the command sent to it. Fig. 6 (a) shows the main menu when users opening this facility. The user should input their user_id and password and automatically they arrive at a certain menu depending on their privileges. Four categories of user may be accepted to operate this facility and they are given different accessibility to control the system. Fig. 6 (b) illustrates when a user without accessibility is exploring the facility, and at this point they are coming to see the product status.

There are also cases in which user having higher privileges may enter the system and perform some operational tasks, for instance giving command to AGV system to move some products to a certain places (Fig, 6 c) or asking some new product from a particular work station (Fig. 6 d). Every user will see some different displays depending on their given privileges. This might allow them to work efficiently associating with the tasks that they have to carry out.

Figure 7 (a) shows the AGV status menu when users opening the facility to see the plant lay out. To see the behaviour of the system, an experimental setup is made as illustrated in Fig. 7 (b). Work station is identified by a bar coded print out as well as the via points along the AGV path. When an AGV passing a via point or entering a station as well as leaving it, the bar code position is scanned (detected) using a barcode reader. This information is directly read by the system and processed by the algorithm.

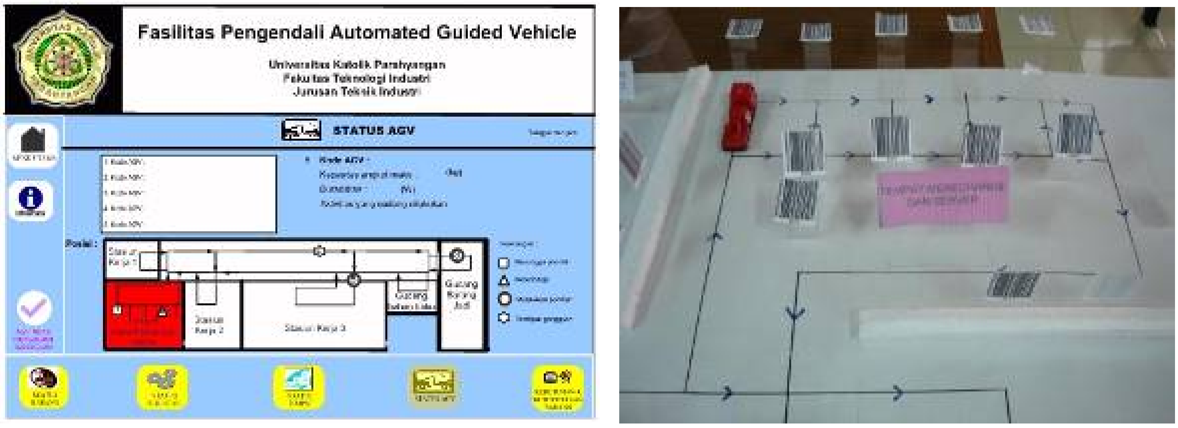
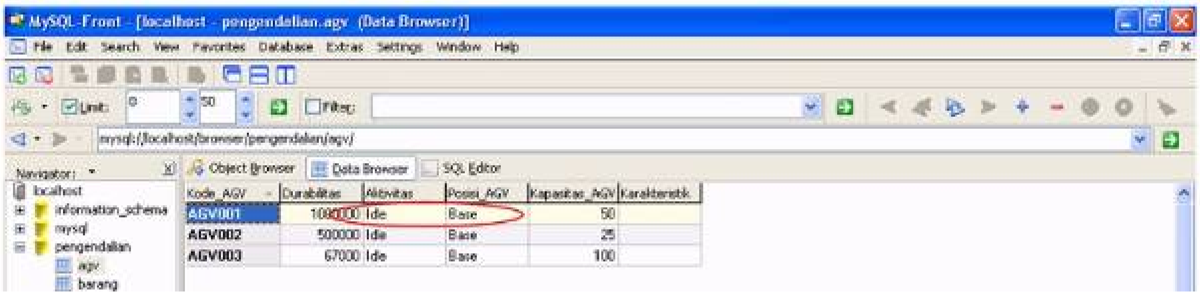


Fig. 7: (a) AGV controlling facility main menu, (b) AGV on the experimental setup (shop floor model).

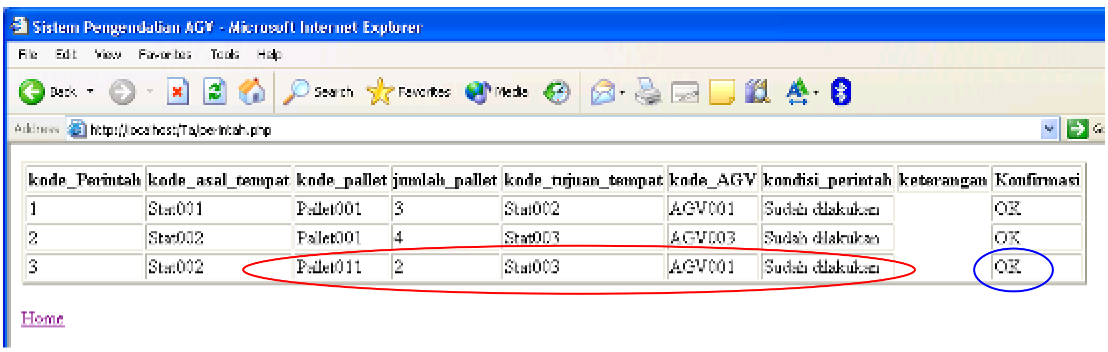
Fig. 8 shows the data in the command table as mentioned in chapter 2.4 above. One can easily see the status of all AGV available, their durability to execute the command, their current positions and carrying capacity AGV of them. This data in the database system can be accessed by the main menu in Fig. 7 (a) and user can input the command to the AGV or just monitoring the real situation on the shop floor model. Execution of commands change the status of AGV, for instance its position will be updated as soon the scanning device sends information to the main controller. This scanning is still done manually as the actual AGV is still under construction.



Kode_AGV	Durabilitas	Aktivitas	Posisi_AGV	Kapasitas_AGV	Karakteristik
AGV001	1000000	Idle	Base	50	
AGV002	500000	Idle	Base	25	
AGV003	67000	Idle	Base	100	

Fig. 8: Monitoring AGV activity using the internet explorer.

One task of moving some products to a particular station was also carried out. This task is in fact categorized as command with multi single commands, and the AGV was set to move only one part at a time. The system was able to determine the type of task that consists of several single command and it performed the task in several times command. Figure 9 shows the condition of task that has been executed and confirmation column is filled by OK sign.



kode_Perintah	kode_asal_tempat	kode_pallet	jumlah_pallet	kode_tujuan_tempat	kode_AGV	kondisi_perintah	keterangan	Konfirmasi
1	Sta001	Pallet001	3	Sta002	AGV001	Sudah dilakukan		OK
2	Sta002	Pallet001	4	Sta003	AGV003	Sudah dilakukan		OK
3	Sta002	Pallet011	2	Sta003	AGV001	Sudah dilakukan		OK

Fig. 9: Confirmation after the AGV finishing all the assigned tasks.

Fig. 10 shows the AGV position is obtained by scanning the bar code placed on the AGV lines. On the AGV it self, there is also one bar code as it self identification sign. This simple experiment gives a good understanding how to develop a data base system that can be used to collect, store, maintain as well as to be accessed by some user from different locations. This is really useful when a complex and dynamical system like production line can be monitored and controlled remotely.

Fig. 10: Simulation of bar code scanning of an AGV at a certain position in the line.

4. Conclusions

Some simple experiments show that it is possible to monitor activities of an AGV within a modeled production lay out and even to command an AGV to move a product from one work station to another. When a command consists of moving several products, then the AGV automatically executes it in several single time command until the whole task is fulfilled. Some important information are available and can be easily displayed to the user using the internet explorer. Within this monitoring facility, every updated information in the data base are displayed in association with the user's need. Users with different category can have different accessibility to work within this monitoring and controlling facility. This facility can be run from different places as long as internet connection is available. Future research is to analyze the condition when there are many moving AGV on the same path and developing algorithm to avoid any possible collision.

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