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Integration of coin-operated ordering machine and delivery system

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Abstract : *This paper describes how to design and create a coin-operated food ordering and automatic delivery system with a low cost and highly efficient creation method that uses computer aided drafting and rapid prototyping (RP), and how to design and achieve mechanisms of coin sorting and coin pushing for change etc. Holtek's microcontroller HT66F70A is used as the main control core and combined with infrared sensors, an electromagnetic gate, a Bluetooth module, mobile phones and a tablet, and a DC motor to create three main parts, i.e. food ordering, payment and automatic delivery systems.*

Keywords *-automatic delivery system, food ordering system, coin-operated vending machine, system integration, automatic change return*

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I. INTRODUCTION

To make life better or more convenient, human beings do all they can to create and invent things and even pursue automation that enables mechanical equipment to replace labor and significant saving of labor with only the need for workers who administer control and equipment maintenance. Mechanism design with computer aided drafting (CAD) plus direct printing of physical prototypes with rapid prototyping (RP) not only saves a lot of creation costs in mold making in traditional fabrication, but also makes the creation process faster and more convenient. In addition, conceptualization is completed by leveraging various tools and equipment including microcontroller development and application combined with the use of Bluetooth and infrared modules and a tablet app to design a complete automated food ordering and delivery system that reduces or even eliminates labor expenses.

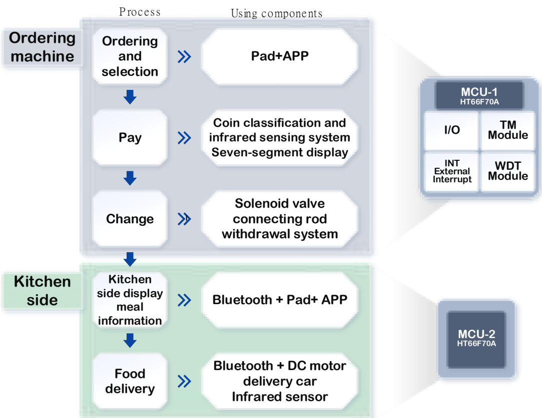

Fig. 1 Organization chart of system processes and components

II. SYSTEM DESIGN

The system mainly consists of HT66F70A as the core microcontroller (MCU) that receives input signals from components such as a tablet app and infrared sensors and controls the connected circuits of peripheral devices in accordance with the instructions and response methods provided by a predefined program. The system is created with different component combinations, as shown in Fig. 1 organization chart of system processes and components.

III. METHOD

Mechanism design involves build with intensive use of CAD as well as 3D printing. Now, 3D printers are widely used and rapid technology today has enabled the development of many different printing methods with printing materials ranging from solid, powder to liquid forms, as shown in Fig. 2 organization chart of types of 3D printing and material categories.

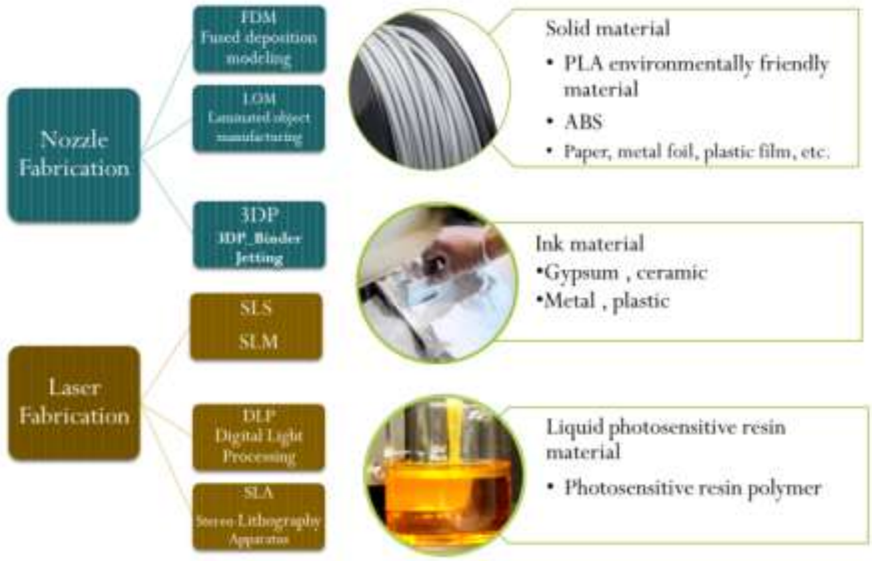

Fig. 2 Organization chart of types of 3D printing and material categories

Fabrication methods can be categorized into kinetic and radiant energy based ones that share similar principles. Printing of consecutive layers that stack up on platforms and bonding with solid materials that are melted by heat or powder materials are kinetic energy based fabrication methods. [1,2] Other methods involve photocuring of liquid photosensitive resins with radiation or melting and sintering of metal powder with high energy laser.[3-5] In this paper, a FDM printer is used.

To achieve automatic payment, mechanisms of different combinations are designed. First, different diameters, weights and materials of coins themselves can be used for sorting. Table 1 is a data sheet of New Taiwan dollar coins by diameter and weight.

Table 1： Data sheet of New Taiwan dollar coins

Pattern	Description
	Diameter: 20 mm. Weight: 3.8 grams. Material: copper 92%, nickel 6%, aluminum 2%
	Diameter: 22 mm. Weight: 4.4 grams. Material: copper coin (copper 75%, nickel 25%)
	Diameter: 26 mm. Weight: 7.5 grams. Material: white copper (copper 75%, nickel 25%)
	Diameter: 28 mm. Weight: 10.0 grams. Material: blue aluminum copper (copper 92%, nickel 2%, aluminum 6%)

Gravity combined with holes in different widths enables coins to fall through corresponding holes due to loss of support and drop into the coin cartridges below. In this way, coins are sorted, as shown in Fig. 3. By default, NT$1 coins with the smallest diameter drop first and are followed by NT$5, 10 and 50 coins. NT$50 coins with the largest diameter are placed in the last position on the slope track. In this way, coins with the smallest diameter will first fall through the first hole, whereas larger NT$5 coins cannot fall through the NT$1 coin hole and will continue to slide until they fall into the corresponding cartridge through the NT$5 coin hole. Therefore, this method enables coin identification and sorting for collection.

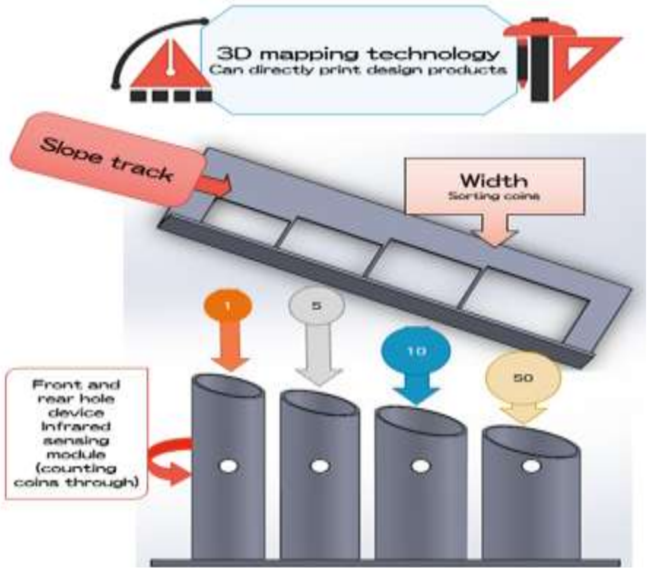

Fig. 3 Schematic of coin sorting

After sorting, coins drop into the coin cartridges below that are connected to the bottom, where they naturally stack up.

In addition, coin counting is designed for each cartridge with an infrared transmitter and receiver placed in parallel at the bottom of the cartridge. Each coin cartridge is equipped with a transmission and reception device, as shown in Fig. 4. In this way, the sensor in the cartridge is interrupted each time a coin drops and the system will count the amount of the coin. Thus, the amount of inserted coins is calculated and shown in the segment display on the panel.

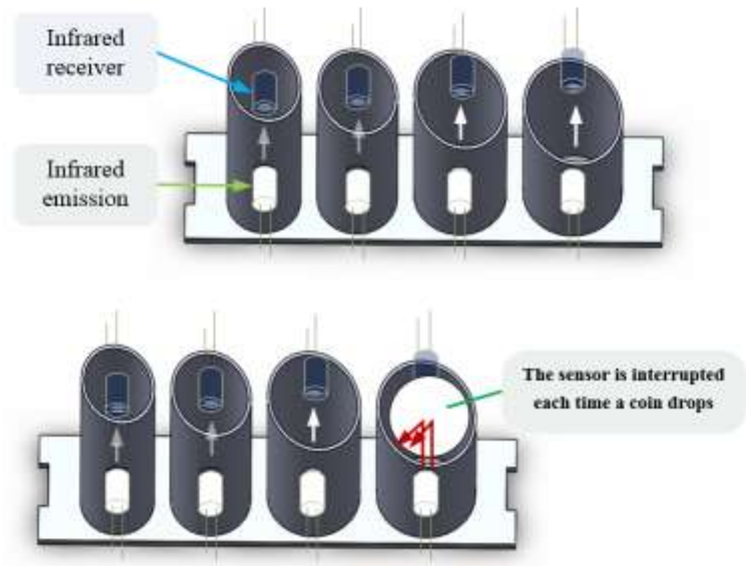

Fig. 4 Schematic of infrared transmission and reception devices

Lever linkage coin pushing

An electromagnetic gate is used as a coin return component. However, as the electromagnetic gate alone is unable to push the coin due to the short working distance and the weak and insufficient push force provided by the spring, the addition of a lever is designed to improve the pushing distance and the electromagnetic force is leveraged for improvement of coin pushing.

After the combination with the lever, the electromagnetic gate is positioned with the shaft center as the pivot when powered off and its force applying electromagnet end retracts and drives the coin pushing end to push the coin when the electromagnetic gate is powered on. Therefore, the application of the principle of the lever enables the working distance to increase from merely 10mm to 40m, as shown in Fig. 5, thus achieving the effect of coin pushin

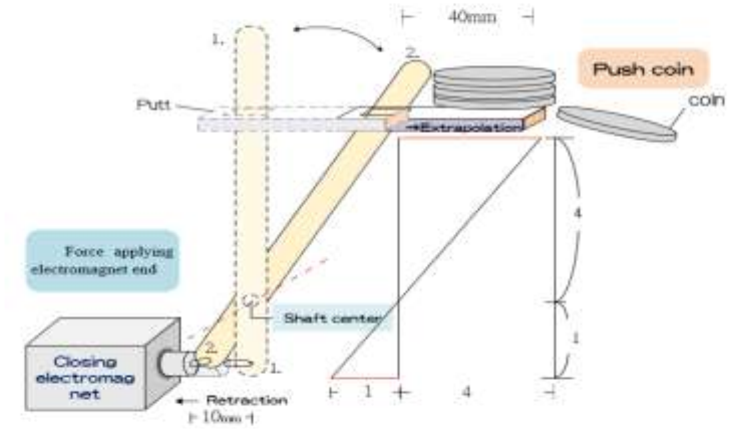

Fig. 5 Schematic of improved pushing distance achieved by lever linkage coin pushing

When the customer operates until the change return step, the system will automatically calculate the amount to be returned in coins. Then, the coin cartridges below combined with the lever pushing track, the installed lever and holes that allow coins to fall through will enable the lever linkage coin pushing system to return one coin each time it pushes the coin, thus completing the coin return action, as shown in Fig. 6.

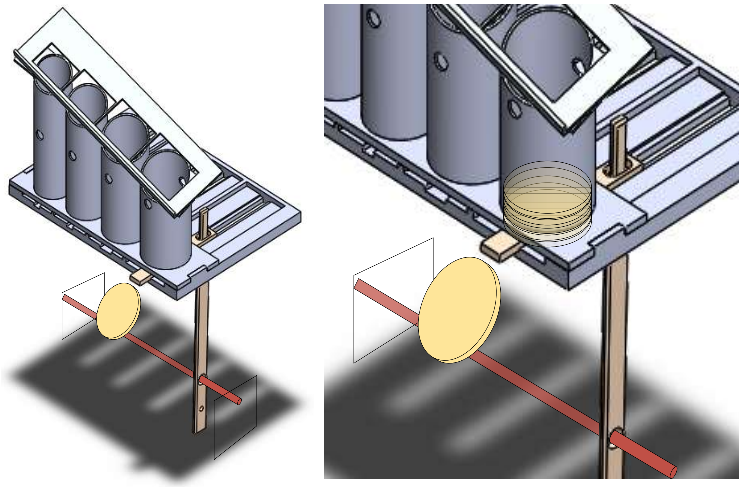

Fig. 6 Schematic of coin return

The track-based food delivery wagon system consists of commercially available toy wagons, one track and food serving plates and the wagon for demonstrating how it operates for food delivery is shown in Fig. 7. The components inside the wagon include a DC motor, a gear mechanism and bounce-back button controlled power. The circuit inside the wagon is modified to include a HM-13 Bluetooth module, an infrared sensor module and a power control circuit.

Fig. 7 Modified food delivery wagon in completion

An infrared sensor module [6] is used as the pairing component for food delivery. An infrared receiver is mounted on the wagon and an infrared transmitter is installed in front of each dining seat. After receiving the instruction, the wagon will set off and deliver the food to the designated seat. When receiving the signal sent by the infrared transmitter in front of the seat, the wagon will stop and the food delivery is completed.

The exterior design of this machine invention is shown in Fig. 8. The components are placed in the cuboid body of the machine. A smart tablet is inserted in a tilted manner into the top of the body. The tilt angle makes it easier for the user to read and operate. A seven-segment display is inserted at the top right corner of the tablet panel. When coins are inserted, the tablet can instantly perform the calculation and show the amount. A window for repair and maintenance is installed in the machine for easy adjustment by maintenance workers. A change return port is installed at the bottom of the machine and the returned coins will naturally drop into the port.

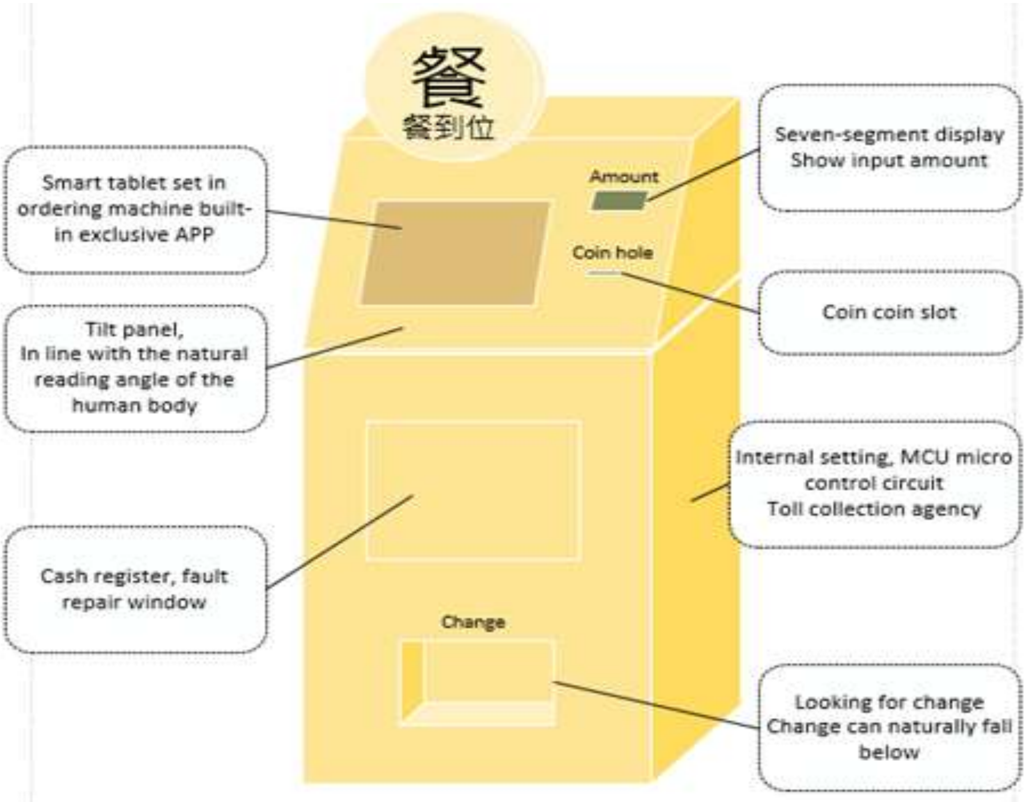

Fig. 8 Illustrated exterior of the coin-operated food ordering machine

The layout of the kitchen is shown in Fig. 9. A tablet that receives information is set up in the kitchen. The tablet also acts as the on/off control for transmission. Arrangement of the seats in the dining area must be connected with the tables and in alignment with the automatic food delivery track so that food can be delivered to target seats over the table surface. Food delivery wagons will eventually return to the kitchen for next delivery.

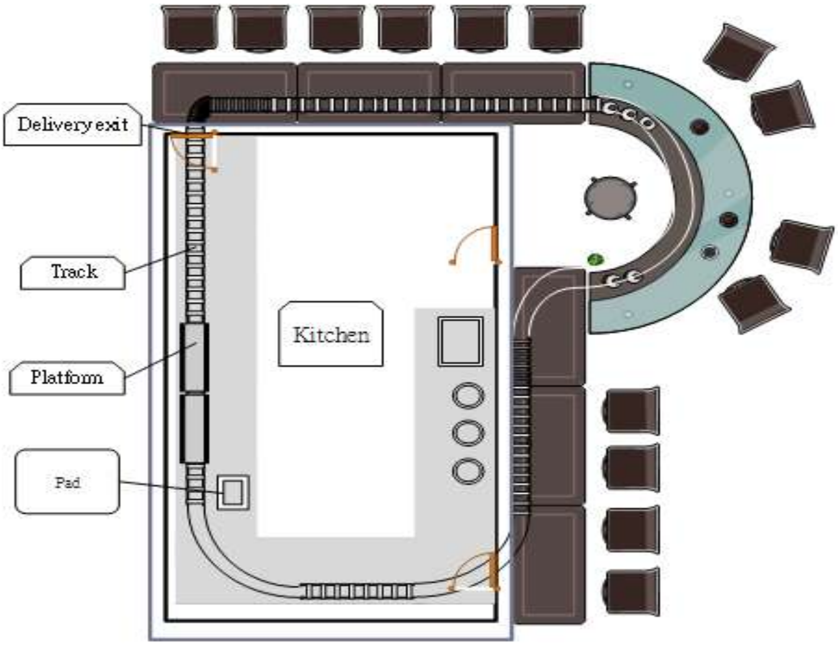

Fig. 9 Concept rendering of kitchen and dining area layout

IV. RESULTS

(1) Coin detection experiment and analysis

This section describes accuracy testing for the coin detection system. The four different types of coins are inserted 20 times each to see if the system can accurately detect them.

Table 2. Detection success rates in 20 times of coin insertion by type of coins

Success rate / Coin type	Coin detection success rate
NT$1 coin	100%
NT$5 coin	95%
NT$10 coin	95%
NT$50 coin	95%

The coin detection testing enables preliminary determination of factors that may affect the results. The reason why NT$5 coins are stuck on the slope track may be excessive friction, overly low tilt angle of the slope track, or occurrence of shaking when the slope track is receiving coins, hence compromising the accuracy of coin sliding.

(2) Coin return testing

Stability testing for the coin return system involves multiple settings of number of coins to be returned and coin return times. In each coin cartridge, 1-10 coins are stacked up respectively for 10 times of coin return. It is recorded whether coins are successfully returned each time to collect the statistics of coin return accuracy. Finally, factors that may affect the results are explored.

Table 3. Accuracy in the coin return

Success rate / Coin type	Money return success rate		
	Stacking coins 1~5	Stacking coins 5~10	Overall 1~10
NT$1 coin	100%	90%	99%
NT$5 coin	100%	60%	96%
NT$10 coin	100%	0%	77%
NT$50 coin	100%	0%	54%
Overall	100%	64%	81.5%

The resultant statistics show that stack-up of more coins can affect the results of coin return. The main reason may be that the push force provided by the lever is insufficient to push coins, hence hindering coin return. It may also be that the electromagnetic gate shakes during coin pushing, hence destabilizing the mechanism and causing coins to become stuck.

V. CONCLUSION

Coin-operated unmanned vending machines for product selection such as beverage vending machines and claw cranes are already commonplace in the marketplace. This is because unmanned vending machines enable no human involvement in store tending and consequent significant saving of labor costs. This paper provides a system that combines a microcontroller with an app, Bluetooth, infrared sensors and an electromagnetic gate and lever linkage mechanism, as well as a low cost and time-saving creation method that uses 3D printing for rapid prototyping. We also extend this unmanned vending system to restaurants. The combination of a microcontroller with Bluetooth and infrared sensor controlled automatic food delivery wagons in the system enables real unmanned food delivery. This means that unmanned vending is not restricted to selling of stock goods such as canned/bottled beverages and snacks only, but can also sell fresh and prepared foods and complement human-based services in restaurants or other types of stores.

Acknowledgements

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