



# A Detection and Information Processing Model Based on an Automatic Mechanism for Tax Payment Control in Developing Countries

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**Abstract.** The foundation of humanity is nowadays based on ways of living that can take many forms including controlling living conditions, reappraising work practices and developing new technologies. However, most of these activities are done to satisfy people's needs, but they have a negative impact on their health and well-being. This is the reason why man seeks ways to develop and protect himself from fatigue and anything that can harm his health by using modern technology that reduces the consumption of resources. Recently, the most used modern technology is based on the "automatism" model which is very useful in multiple fields. The technology of automated systems is rapidly evolving in terms of components, structures, advanced control systems and application areas. The objective of this paper is to implement an automatic mechanism to ensure a better and wonderful control when collecting taxes especially in developing countries. The proposed mechanism is based on a case of paying parking tax. The mechanical part of our system is controlled by an ARDUINO micro controller under which works in parallel with a Windows application on a computer to control a servomotor that operates the barrier. The detection of the coordinates of the taxpayer is done using the radio frequency identification. This control model is composed of detection and information processing system and a mobile barrier whose structure is adapted to the opening or closing geometry of the taxpayer passage.

**Keywords:** Microcontroller · servomotor · RFID · automatic mechanism · tax payment control · developing country

## 1 Introduction

All people in the world seek to develop quickly and to protect themselves against all that can harm their health. Technology is one of the things that handle such

human issues by reducing the consumption of resources. The field of technology is advancing so fast at an extraordinary rate. Indeed, the new era of information technology which involves for instance the transmission and storage of information in electronic formats [1] have been adapted by different institutions and organizations around the world. The “automatism” is one of the fruits of that information processing technology. The automatism is very useful in multiple fields among others, industrial, medical, military and embedded systems or even in everyday human life. The technology of automated systems is rapidly evolving in terms of components, structures, advanced control systems and application areas. Thanks to this automation technology, some countries that have reached the path of development are progressing at an exciting step and rendering them extremely rich [2,3]. However, in some developing countries, this technology has not been yet developed to an appropriate level.

The developing countries are seeking to achieve sustainable development and are engaged in the fight against the squandering of national wealth, corruption, tax embezzlement and tax evasion, as these are major challenges that hinder development. For a country to prosper economically, it is very useful to use and accumulate wealth from all possible sources, including taxes, according to the law. Taxes play an important role in the economic growth of developing countries [4]; their misappropriation hinders economic decollation. Meanwhile, taxes tend to go through illegal channels and it has been observed that the taxpayer pays taxes without receiving a receipt in return. The tax collector keeps the small amount in his pocket, instead of doing the job properly assigned by the government.

In many developed countries like Brazil, after implementation of Digital Book-Keeping System (SPED) in 2009, tax collections rose at a compound annual growth rate (CAGR) of 8.7% from 2010 to 2015, as compared with a CAGR of 7.6% from 2007 to 2009 [5]. Moreover, since 2016 in China, a powerful platform for pooling tax data from all levels of tax bureaus across a country has been implemented to facilitate both taxpayer and tax authority engagement. This platform especially enables the tax authorities to closely monitor invoice creation to detect fictitious invoices, ensuring the integrity of invoice information and the authenticity of filing data [6].

Furthermore in developing country like Kenya, it was estimated through a 2015 report that Sh639 billion were lost annually in tax evasion by multinational corporations. After tax procedures became fully digitalized in 2016, the Kenya Revenue Authority (KRA) collected 1.366 trillion in the 2016/2017 financial year; an added Kshs 115 billion from its previous year’s collection [7]. Based on the introduction of ICT taxpayer Department of Tanzania Revenue Authority (TRA), the revenue collection increased from TZS 204,397.5 Millions in February 2001 to TZS 1,605,751.2 Millions in 2008 while revenue contribution share rose to 41% in September 2008 from 23% in February 2001 [8].

For the case of Burundi Revenue Authority (BRA), the innovations introduced by the reform have real economic and social benefits to the citizens of Burundi. It has organized functional lines which were focused on taxpayer

segmentation with the major aim of maximizing the voluntary tax payment. Therefore, the use of automated tax payment system in Burundi enabled the BRA to increase its tax collection due to the implementation of a controlled tax evasion system introduced in BRA [9].

In fact, to improve the social services, critical or poor communication infrastructures and other public sectors, the ability of each country to collect taxes is vital. The goal of this study is therefore based on the implementation of the technology in general and automation in particular for especially developing countries, with the intention of financing those services for the welfare of human being.

## 1.1 Literature Review

Nowadays, there exist general issues that developing countries are facing from technological changes. Some promising examples of technological innovation and application in tax administration and tax policy have been proposed in literature. During the last few years, automatic mechanism and/or intelligent systems have been developed to satisfy people's needs. Those systems have been used in multiple fields including intelligent transport systems [10], medical [11], industrial [12], internet of things (IoT) [13,14] and embedded systems [15,16] or even in everyday human life [17,18]. For instance, authors in [10] developed a hybrid approach to solve the problem of vehicle position prediction under multi-GPS failure conditions such as free and partial GPS failures as well as short and long full GPS failures. Moreover, Kuwik et al. [11] proposed a home refrigerator (which stores vaccines) that is programmed such that it continues to monitor the action of opening and closing the door to check if the patient is taking medication regularly, given that the patient takes medicine at regular and known time intervals. In [15,16], authors implemented a smart refrigerator from which information about the products remaining inside and the status of its door can be obtained using the radio frequency identification (RFID) technology. The research work in [17] proposed the realization of an electronic cane automating the detection and recognition of fixed and moving obstacles can provide more safety for blind people. Chayma Bahhar et al. [13] worked on a system to monitor the presence of a fire and the concentration of gas in real time in the atmosphere whereas authors in [18] presented the creation of a prototype of a low-cost smart home whose home automation would be controlled by mobile devices.

Although the aforementioned mechanisms have been implemented to satisfy rapidly people's needs in different fields, the country's economy is essential and should also be taken into account for a good human living. Different approaches have been developed in the literature with the intention of achieving a high-income economy, especially in developing countries. One of the strategies to enhance the country's economy is the way the taxes and the expenses are managed. The automation technology is quite primordial to reach the significant economy through the collection of the taxes. Indeed, researchers in [3] have highlighted different methods in order to collect taxes more efficiently by changing

the law, giving deadlines and changing the tax collector from time to time. Moreover, authors in [19], have set up an intelligent system to monitor who pays and who does not pay taxes and to check whether tax collectors are collecting taxes properly. However, for this system, human intervention is still very important, and the more human intervention there is, the higher chances of corruption and tax evasion colluding.

## 1.2 Objectives and Contributions

The main objective of this study is to develop a detection and information processing model based on an automatic mechanism for parking taxes payment control especially in developing countries. To achieve this, an electronic barrier that automates the detection and recognition of the taxpayer's information is implemented. The main benefit of the proposed mechanism is that the automatic closing and opening of the taxpayer passage can bring more security in the collection of taxes. Specifically, the proposed system automates the control, payment, opening and closing of the gateway at the parking to minimize human intervention in the tax collection process. This system will improve and purify the way taxes are collected. In other words, the probability of collecting taxes using illegal channels will be highly reduced. Therefore, the taxes will be fully channeled to the public treasury.

To experimentally design and implement the proposed system, different components such as a microcontroller named ARDUINO UNO, the RFID reader, the tags and the servomotor are used to detect the information of the parking taxpayer and provide him with several types of information including the status "payment" or "non-payment". This status makes him eligible for what he is entitled to. The mechanism also presents the effectors that implement the instructions of the command to let the taxpayer pass or not.

The remainder of this paper is organized as follows. We present the description of the used circuit tools for tax payment control in Sect. 2 whereas Sect. 3 highlights the proposed detection and information processing model based on an automatic mechanism for tax payment control. Section 4 illustrates the frame design and development of the system and finally conclusion and future works are presented in Sect. 5.

## 2 Description of the Used Circuit Tools for Parking Tax Payment Control

In order to normally manage the collection of taxes and their routing to the public treasury, we propose an automatic tax payment controller mechanism that can automate the control, opening and closing of the taxpayer passage. The proposed mechanism is composed of several parts. It is equipped with a micro-controller (ARDUINO UNO) and a computer which are the information processing units and a sensor (RFID reader) to detect the information of the taxpayer. In order to perform a wonderful control and validate its eligibility (having

paid or not the taxes), an effector (servomotor) that executes the instructions of a micro-controller (opening or closing) is taken into account. Moreover, an electric sensor (push button) is used to obtain information on the state of passage of the taxpayer. On the other hand, a light signal is implemented to ensure a communication of the system with the external environment. The whole process is summarized in the block diagram of the circuit (Fig. 1) [17].

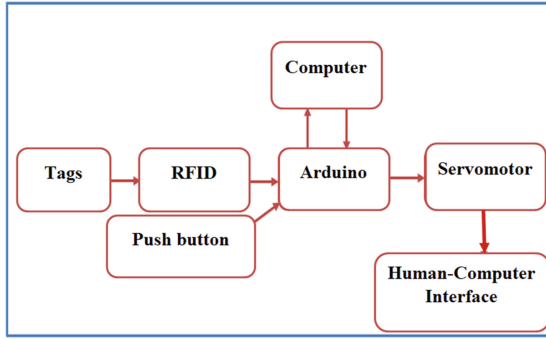


Fig. 1. Global block diagram of the circuit

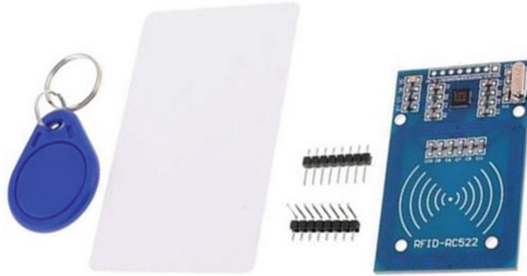
## 2.1 The Radio Frequency Identification (RFID) Components and Operation

A complete RFID solution allows the integration of the data flow into the company's information system [20]. It includes the tag and the reader. The tag is one of the most widely used identification methods to embed a serial number or data sequence in a chip and to connect this chip to a small antenna. This pair (silicon chip + antenna) is then encapsulated in a carrier (RFID tag). The reader/writer is made of a circuit that emits electromagnetic energy through an antenna, and of an electronic that receives and decodes the information sent by the transponder and sends it to the data collection device. The RFID reader is the element responsible for reading the radio frequency tags and transmitting the information they contain (EPC code or other, status information, cryptographic key...) to the next level of the system (middleware). This communication between the reader and the label is carried out in four stages:

- The reader transmits by radio the energy necessary to activate the tag;
- It then launches a request interrogating the nearby tags;
- It listens to the answers and eliminates duplicates or collisions between answers;
- Finally, it transmits the results obtained to the applications concerned.

The communication between the reader and the tag takes place via the antennas that equip both of them, these elements being responsible for the radio

frequency radiation. The power of the reader is to be combined with the appropriate antenna, which determines the optimal reading range. The RFID reader and tags are presented in Fig. 2.



**Fig. 2.** RFID reader and tags

The technology of the RFID is based on the emission of electromagnetic field by a “reader”, or “fixed element”, which is received by the antenna of one or more labels, or “deported elements” which transmit a signal according to a given frequency towards one or more labels located in its field of reading. This electric or magnetic field serves as a vector for the information between the tag and its reader, as well as a support for the activation energy of these tags. More details related to the RFID components and its operation can be found in [17,20–23].

## 2.2 The Servomotor

A servomotor aims to produce a precise movement in response to an external command, it is an actuator (system producing an action) that integrates electronics, mechanics and automation. A servomotor is capable of reaching predetermined positions in the instructions given to it and then maintaining them.

As presented in Fig. 3, a servomotor consists of a DC micro motor, a gearbox at the output of this motor that decreases the speed and increases the torque, a potentiometer (acting as a resistive divider) that generates a variable voltage proportional to the angle of the output shaft, a shaft protruding out of the housing with different arms or wheels for attachment, and an electronic servo device [24].

In the ARDUINO system, the servomotor is mainly used in robotic applications. The servomotor has three wires to operate, the red and black (brown) are used for its power supply while the orange (yellow or white) receives the control signal. The servomotor has the advantage of being angularly servo-controlled, which means that the output axis of the servomotor will respect the instruction sent to its input. Even if an obstacle intervenes to change the orientation of its trajectory, the servomotor will try to keep the position. For precise position

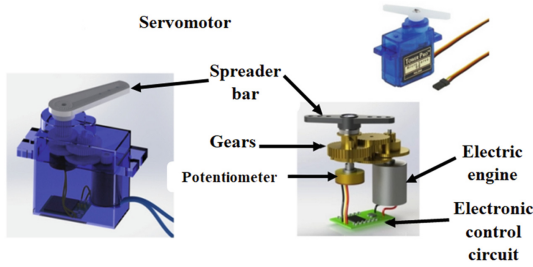


Fig. 3. Composition of the servomotor

adjustment, the motor and its control are equipped with a measurement system that determines the current position [25]. Figure 4 indicates the control signal illustration of servomotor.

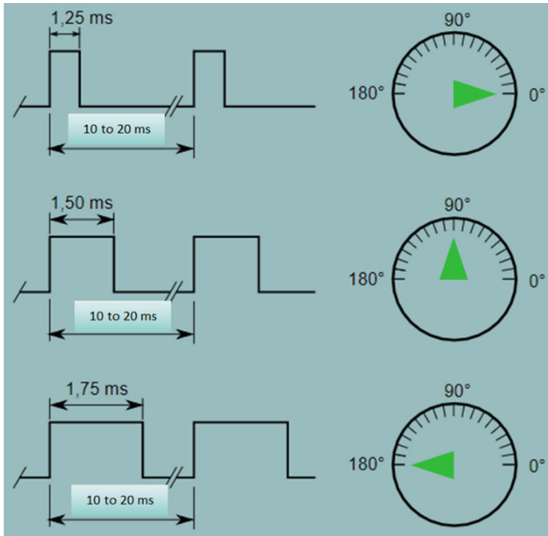


Fig. 4. Control signal illustration

### 2.3 The Light-Emitting Diode (LED)

In order to communicate with the users, a traffic light (monitored by LED) which plays the role of man-machine interface is used. The red, green and yellow lights of the traffic signals respectively indicate “no crossing of the signal”, “authorization to pass the signal” and “forbidden to pass the signal”. In the two-color system, red light means no crossing of the signal, and green light allows to pass the signal. The appearance of the red light while the green light is still on has the

same meaning as the yellow light in the three-color system [26]. In this study, a two-color signal is used to ensure and facilitate a prohibition/permission to cross.

## 2.4 The Push Button

The N.O (Normally Open) push button, when clicked above, sends information to the control part (ARDUINO board and computer) about the passage of someone and finally the control part orders the system to close the passage.

## 3 The Proposed Detection and Information Processing System Based on an Automatic Mechanism for Parking Tax Payment Control

As the proposed automatic tax payment control system will need taxpayers' information on tax payments, it must be connected to the database management system, in which taxpayers are registered. The model flow chart in Fig. 5 illustrates the implementation of the detection and information processing algorithm based on an automatic mechanism for tax payment control. The model comprises of the Windows application connected to the local database management system to better perform the design and validate the model results. The main six (6) steps of the algorithm are numbered in the flow chart and are summarized as follows:

**Step 1:** Opening the program

**Step 2:** Waiting for the detection of the information by RFID

**Step 3:** Verification of the information by the information processing unit (valid or not)

**Step 4:** The servomotor initializes to apply the information from the processing unit.

**Step 5:** Detection of the information by the servomotor

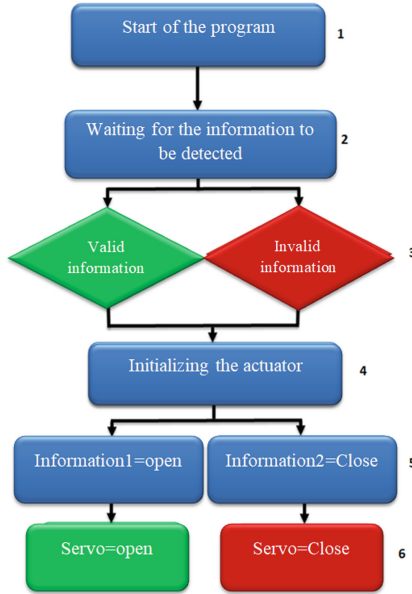
**Step 6:** Implementation of the instructions that the information received by the servomotor holds

## 4 Frame Design and Development

With the intention of experimentally validating the effectiveness of our proposed method, a design and development of the system are carried out based on the hardware tools monitored by the Windows application (software).

### 4.1 Materials and Method

**Model Design and Deployment.** During this study, the used materials are composed of the ARDUINO board, the computer, the sensor circuit (RFID and



**Fig. 5.** The proposed model flow chart

the push-button) and the servo effector circuit. The technical parameters of the used servomotors are highlighted in Table 1.

**Table 1.** Technical parameters of the used servomotors

|                             |                         |
|-----------------------------|-------------------------|
| Reference and specification | <i>SG90</i>             |
| Weight                      | <i>9g</i>               |
| Torque                      | <i>1.2kgf.cm</i>        |
| Operating voltage           | <i>5V</i>               |
| Stem diameter               | <i>approx.4mm/0.2in</i> |
| Speed of rotation           | <i>0.12/60orad/s</i>    |
| Angle of rotation           | <i>180o</i>             |

Moreover, Fig. 6 indicates the connection of the aforementioned circuit components for the control unit. Specifically, to implement the proposed system, we used an ARDUINO UNO board, sensors (RFID-RC522 reader and push button), lanes, a test plate, LEDs, an effector of rotary detecting the desired angle and the IDE ARDUINO software. The ARDUINO board is connected to the computer via USB. The communication between the ARDUINO is provided by a Windows application developed in Visual Studio 2010. Figure 7 indicates the initialization of the tax control application results.

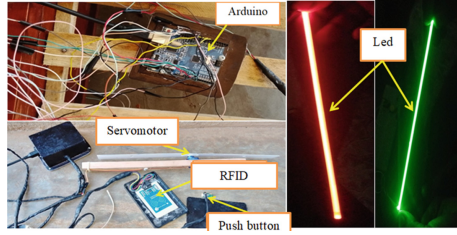


Fig. 6. Connection of the control unit

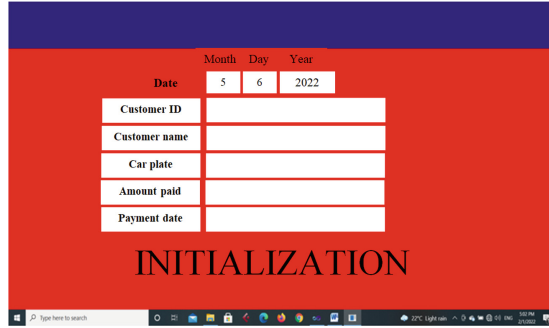


Fig. 7. Parking tax control application

After the implementation of the complete assembly of the system, ARDUINO was connected with C sharp so that there is a communication between this card and the computer holding the information corresponding to the payment or the non-payment of the taxpayer.

**The Design of the Controlled System Unit.** The controlled part is set in motion by the effector of the proposed control system. The proposed mechanism is subjected to three forces that are the weight of the rod that we can connect to the head of our mechanism and the two moments (the motor torque and the moment that will be developed by the rotational movement of the rod used) as shown in the Fig. 8; where  $P$  is the force developed by tripod weight,  $C_1$  is the torque developed by the tripod and  $C_2$  is torque developed by the movement of the rod ( $C_T$ ).

By analyzing the mechanism presented in Fig. 8, we notice that all the reactions it uses to react against any force applied on it, are equal to the weight of the tripod. For this, at each support of the tripod we find  $R = \frac{P}{3}$  such that  $P = \sum_{i=0}^n R_{X,Y,Z}$  and

$$C_1 = Pd_1 \text{ where } d_1 = [(ab \times \cos(35^\circ)) + 20] \text{ cm}$$

$$C_2 = C_m + C_T \text{ where } C_m = 1.2 \text{ kgfcm, } C_T = Fd_T \text{ and } F = \frac{C_m}{r}$$

For the proposed mechanism to function normally without imbalance,  $\vec{P}^i$  must

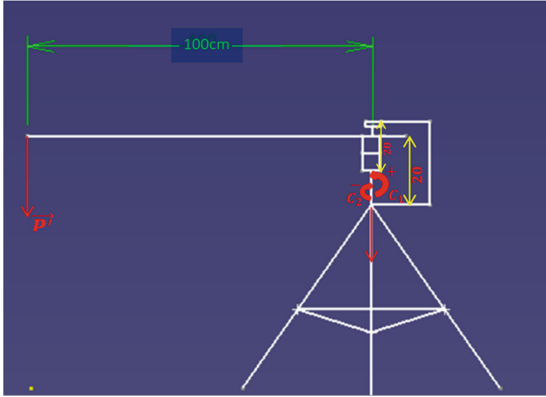


Fig. 8. Inventory of the forces applied to our mechanism that can unbalance it

be less than  $\vec{P}$  ( $P' < P$ ) and these two pairs must cancel each other out or  $C_2$  must be less than  $C_1$  ( $C_2 \leq C_1$ ).

For the present case:

The radius  $r = 17.5 \text{ mm} = 0.017 \text{ m}$

$$F = \frac{1.2 \text{ kgfcm}}{1.75 \text{ cm}} = 0.6857 \text{ kgf}$$

$$C_T = 0.6857 \text{ kgf} \times 2 \text{ cm} = 1.371 \text{ kgfcm}$$

$$C_1 = 2 \text{ kgf} \times (65 \text{ cm} \times \cos(35^\circ) + 20 \text{ cm}) = 146.469 \text{ kgfcm}$$

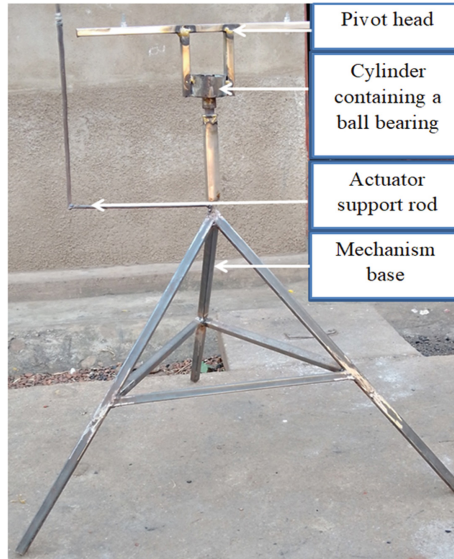
$$C_2 = 1.2 \text{ kgfcm} + 1.371 \text{ kgfcm} = 2.571 \text{ kgfcm}$$

The torque of the presented drive motor is as small as possible. A light weight rod for our motor to drive the gate is needed. To drive a heavy rod, a high torque servomotor is used. Our motor ensures a double function, the drive and the blocking of the movement of the rod. If we use a rod of an important length, we are required to create a braking system of torque  $C_{1,2}$  higher or equal to the torque of the rod. Moreover, it is important to check that the torque developed by the aforementioned rod on which we add the motor torque, is strictly lower than the resistant torque  $C_T$  of the tripod so that this last one does not fall over.

From the above calculations, we can notice that  $C_2$  is less than  $C_1$  ( $C_2 < C_1$ ) which proves that our tripod has the power to stay in balance during the rotation of our barrier. After the calculations based on the control and controlled units, we moved to the deployment and Fig. 9 shows the mechanical part of the proposed model.

## 4.2 Results and Discussions

Figure 10 shows the complete mechanism where the control part to the controlled part are connected. The connection between the control system and the controlled system (mechanical), is ensured by wires that connect the ARDUINO



**Fig. 9.** The mechanical part of the mechanism

board to the servomotor. The latter executes the orders communicated by the computer via the ARDUINO board.

The servomotor describes a rotational movement on a track of a quarter circles and communicates this movement to the head of the mechanism. This head rotates from zero to  $90^\circ$  after checking and validating the conditions allowing the passenger to continue. The test of the automatic tax controller mechanism led us to the expected result of crossing (opening of the barrier) when we present the white card to the information reading module. A control was carried out and our system proved that the person having this card, that is to say fulfilling all the required conditions (the payment of the required month), sees the barrier opening while describing a rotation from 0 to  $90^\circ$  to let the passage and the green led lights up to give green light as shown in Fig. 11.

When we click on the commanded push button, the barrier closes and the red led lights up (Rotation of  $90-0^\circ$ ). Moreover, when we present our key ring that is not in order we have seen that the system recognizes it but the barrier remains closed and the red led remains ON as presented in Fig. 12.

Although the proposed study is based on the implementation of an automatic mechanism to ensure a better and wonderful control when collecting taxes especially in developing countries, it faces some limitations. Indeed, the used tools to get to the current stage have limited capabilities. In fact, there should be an exchange of information between the tax collection authority and this automatic mechanism, as well as an exchange of information between this system and the taxpayers, so that the taxpayer is informed that the tax was paid/not paid or that someone has paid [5].



**Fig. 10.** Complete mechanism



**Fig. 11.** Open Passage (0–90° rotation)



**Fig. 12.** Closed passage

## 5 Conclusion and Future Works

In this work, a detection and information processing model based on an automatic mechanism for parking taxes payment control is developed. The proposed model is implemented based on the hardware equipment and the software part was used to monitor that equipment. Specifically, the ARDUINO board enables to develop in the environment of programming IDE ARDUINO ensuring the reading of information (detection of information) and transmits this information to the computer. The latter comprises of a program of control developed in C sharp which replicates after having searched and validated the information of the taxpayer in a database, a corresponding instruction (paid = opening, not paid= closing). The proposed model detailed the practical aspects of communication between the ARDUINO UNO, its IDE and C sharp via the USB port for serial communication.

Future research will focus on the complete mechanism by extending it to a database management system of the tax administration. Indeed, additional equipment such as global positioning system (GPS), routers and other related equipment are required for allowing the proposed model to exchange information with the tax authority's database. This would enable the taxpayer receiving complete information from that agency's system.

**Acknowledgements.** This work was supported by the Department of Applied Sciences, Burundi Higher Institute of Education.

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