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# SOLAR TRACKING FOR RENEWABLE ENERGY SYSTEM

BY

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**Abstract.** Photovoltaic (PV) systems have been used for many decades. The increasing demand for electricity and the recent change in the environmental conditions led to a need for improvements on the energy sources. The improvements should be sustainable with less carbon dioxide emissions and to be environmentally friendly. Solar PV panel energy has offered throughout the years very good results in energy production systems. Changes in irradiation and the movement of the Sun will decrease the energy production and the efficiency of the PV panels, which is why improvements should be made in this manner. The amount of solar energy captured by a sun collector determines the output power generated for thermal or photovoltaic applications. Accurate solar tracking systems have an important role in the performance of solar collecting technologies. The proposed paper work is designed to detect the presence of the sun and can position the solar panel towards sun’s direction using dual-axis tracking. The system rotates the panel according to the sun position, so that solar power can be properly utilized.

**Keywords:** solar tracker system; image processing; Arduino; stepper motor; web camera.

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## 1. Introduction

The sun is the prime source of energy, directly or indirectly, which is also the fuel for most renewable systems (Tanvir *et al*., 2010). Conversion of solar light into electrical energy represents one of the most reliable and promising energy technologies. This technology is in continuous development, because it is a clean energy, silent, with very low maintenance costs and minimal ecological impact. Practically, it involves no polluting residues or greenhouse gas emissions. The efficiency improvement of the PV conversion equipment is one of the top priorities for many academic and industrial research groups. A PV panel consists of a surface on which numerous p-n junctions are placed, connected together with electrically conducting strips (Julian Chen, 2011).

Due to the continuous change in the relative position of the Sun, the radiation on a PV panel is continuously changing, and therefore reaching a maximum point when the direction of solar radiation is perpendicular to the surface of the panel. In this manner, it is necessary to build a solar tracking system for maximal energy production (Tudoreache, 2010). Some articles can be mentioned which provide the description and design of different dual-axis tracking systems (Aashir *et al*., 2014; Tudoreache & Kreindle, 2010; Tanvir *et al*., 2010; Jeng-Nan & Radharamanan, 2014; Kok-Keong & Chee-Woon, 2010; Summer *et al*., 2015).

Some methodologies to follow the sun across the sky are the open loop and closed loop systems. It has been shown that closed loop systems have a higher efficiency than open loop systems (Aurélio *et al*., 2017).

A Dual-Axis Tracker can produce 30-40 percent more electricity than stationary solar arrays and smoothing of production throughout the day. Some interesting results were shown by comparing the tracking errors with different modes of tracking options.

Solar PV panels and linear concentrating collectors needs only single axis tracking. Dual axis tracking is mandatory for point focusing solar concentrating collectors (Natarajan & Srinivas, 2015).

## 2. System Specification

Dual-axis trackers captures the solar energy more effectively by rotating in the horizontal as well as the vertical axis (Aashir *et al*., 2014).

Movement in two-axis is explained in Fig. 1 which shows the basic idea behind dual-axis tracking.

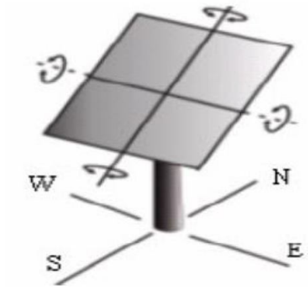



Fig. 1 − Dual-axis solar tracker (Aashir *et al*., 2014).

The stepper-motor based positioning system is very much useful and popular requirement in the industry especially where accuracy is needed.

The mechanism of the tracking system will be provided with two stepping motors in order to control the position of the PV panel. Stepper motors are very useful in precision positioning control applications such as tracking systems. Compared with any other type of motor, the stepper motor is more controllable, more energy efficient, steadier and has high tracking accuracy and suffers little environmental effect. These characteristics of the stepper motor have been considered before implementing the solar tracker system.

This is a digital motor and an accurate position control is possible. The stepper motor rotates on rotation of the bit pattern appearing to its coil. The stepper motor converter provides adequate voltage and current to control the motor. The converter receives control signal from the microcontroller. In this project two unipolar stepper motors were used. Some articles have a very useful guidance and explanation is detailed about the principles of functioning, design and the fundamentals of stepper motors (Precision Step Motor, 2010, Matthew, 2005; Kausik *et al*., 2013; Reston, 2004).

The main objective for this purposed research model is to design a dual axis solar tracking system with a view to assess the improvement in solar conversion efficiency and to get optimum power. The contribution consists in using as Sun position sensor a webcam. The following section the use of stepper motors will be described and the principles of functioning. The fourth section is about the architecture of the image technique used for tracking. In section 5 the description of the hardware set-up will be presented. In the sixth section experimental results will be shown and in the last section conclusions and further improvements will be presented.

## 3. Experimental Setup

The stepper motor that has been used in the prototype has the specifications of 12 volts, 7.5° per step, the number of steps per revolution is

48, 4-phase, and the architecture is of unipolar type. Stepper motors are brushless DC electromechanical motors, unlike a DC motor. The main parts of a stepper motor are the stator, rotor and the shaft. The shaft within the motor actually spins during use and it converts electrical pulses into mechanical movement. When the stepper motor is electrically powered, the current pulses applied to the motor will generate discrete rotation to the motor shaft.

The stepper motor can exhibit continuous rotation as a DC motor, but most importantly each step is defined by a step angle. The speed of the motor shafts rotation is directly related to the frequency of the input pulses. A wide range of rotational speeds can be realized, which is very useful. Another important aspect of this type of motor is that is allows reversing the rotation direction. There are two winding arrangements for the coils in a stepper motor: bipolar and unipolar. The unipolar stepper motors are composed of two windings. Furthermore, unipolar motors could have five or six wires (Țopa *et al.*, 2005). In Fig. 2 a six-wire configuration unipolar motor can be seen.

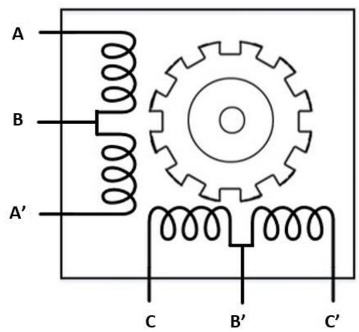



Fig. 2 − Unipolar stepper motor 6-wire configuration.

In the unipolar stepper motor, the currents direction in the stator windings determines which rotor poles will be attracted to which stator poles. The direction of the current is dependent on which half of a winding is energized, and the halves of the windings are wound parallel to one another. Thus, the winding acts as either a north or south pole position, which depends on the half that is powered.

Stepper motor phases can resist rapid changes in current flow and at the end of each step or when it is stationary, they behave like a resistive load and will act according to Ohm's law.

The electrical compatibility between the motor and the converter are the most critical factors which should be considered. Stepper motors are rated with a varying value of inductance. A high inductance motor can provide a great amount of torque at low speeds and low torque at high speeds. Speed, torque and resolution are a main consideration in designing a step motor system and they are designed to run at temperatures ranging between 50º-90º C. However, too much current may cause excessive heating and damage to the motor insulation and windings.

Two important parameters should be considered in the converter specifications: the voltage and the continuous current. In essence, it is about the maximum voltage and the maximum current that the converter can supply to the motor. A great advantage of this type of configuration is that a magnetic pole can be reversed without switching the direction of the current, and the control circuit can be made simple, with a single transistor on each winding, which can be seen in Fig. 3. This figure is used for both stepper motors. By driving the motor with a higher voltage, the chopper can compensate for the back electromagnetic force (EMF). Stepper motors could be driven at several times their rated voltage with the help of a chopper driver. At these high voltage levels the chopper driver controls the current being delivered to the motor by chopping it before it increases to a dangerous level. When the motor absorbs high voltage levels, the chopper will be able to deliver a higher current value to the coils at the start of each step. Due to this fact the torque will be significantly increased even at lower speeds, and it also allows for higher speeds.

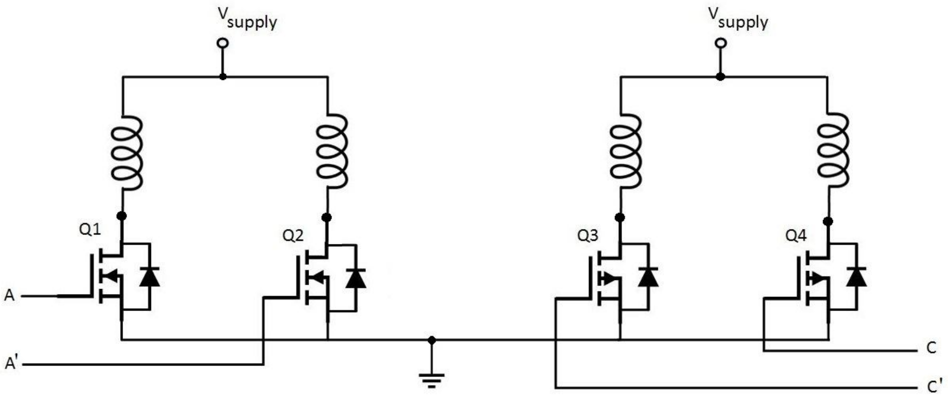



Fig. 3 – Stepper motor converter.

The stepper motor converter receives low level signals from control system and converts them into electrical steps or pulses in order to run the motor. The shaft of the motor requires pulses in order to do steps. The stepper motor speed and torque performance is dependent on the flow of current from the converter to the motor winding. Wires from the controller have to be connected to the dir and step ports of the converter. The converters used in this research are based on FET transistors meaning that they are constant current converters. Transistors denoted Q1 and Q2 (or Q3 and Q4) should never close at the same time. If it happens then a really low-resistance path will be created between power and GND, effectively short-circuiting the power supply. It can destroy the transistors, or something else in the circuit. When Q1 is connected, the motors coil will be connected to the power supply and current will run through the motor to energize it. When Q2 is connected the same procedure is made but the motors shaft will spin in the opposite direction.

The inductance is the main factor that retains the flow of current and delays the time it takes for the current to supply the windings. Good motor performance could be achieved at low inductances, because the current could supply the windings faster. The converter circuit was constructed to supply the motor with higher voltages than the rated voltage.

## 4. Image Based Technique for Tracking

The most important factor in the performance of a photovoltaic solar panel, is the amount of solar irradiation that reaches its surface. Solar irradiance on a panel varies with geographic location, time, and orientation of the panel relative to both the sun and the sky. For a given geographic location, the amount of radiation incident on a surface can be increased by utilizing a tracking system that mechanically changes the orientation of the panel so that it points more closely towards the Sun's position. Two-axis tracking systems have an increased mean surface irradiance relative to a fixed panel.

Two methodologies to follow the sun across the sky can be mentioned, namely, closed loop or feedback control system and open loop tracking systems. Differences between open-loop and closed-loop control systems, an open loop control system acts completely on the basis of input and the output has no effect on the control action. A closed loop control system considers the current output and alters it to the desired condition. Open loop systems are based on the solar position through means of position detectors such as a webcams, so that the solar tracker can be positioned according to the obtained information. This is the method that was applied in this research paper. Closed loop systems consist in the use of devices to find the direction with the maximum amount of incident radiation or the maximum amount of solar irradiation.

In perfect tracking condition, the angle between normal to solar collector's surface and sunbeam, known as incident angle is zero to gain maximum energy collection and efficiency. The radiation applied on a panel surface can be divided into two components. Firstly, the direct beam radiation that comes from the Sun and this can be approximated by different methods. In essence, it is used to describe solar radiation traveling in a straight line from the Sun down to the surface of the earth. When the sky is clear and the sun is very high in the sky, direct radiation is around 85% of the total insolation striking the ground. Secondly, the diffuse radiation that arises from the light scattering produced in the atmosphere due to reflection and absorption by air molecules.

Consequently, an ideal orientation for a photovoltaic panel will be towards the beam component. In cloudiness weather conditions, the Sun's position may not be true due to possible solar reflections. Also the diffuse radiation is affected in great proportions due to solar radiation, light spectrum, incident angle and air layer thickness.

The main idea behind this research is to develop a tracking system based on image processing, which searches the optimal orientation of a surface, related to the Sun position using the two-axis tracking method. The architecture of the system is presented in Fig. 4.

The hardware design of this project includes the Arduino Uno microcontroller, a webcam, two stepper motors with their converter circuits. A computer is used to process the images captured from the webcam, and the motors will move the PV panel accordingly. The image-based solar tracking technique is implemented to this system, with the use of a low-cost webcam, as a sensing device, having a highly developed technological platform, to be used in such a tracking system, and can easily adapt to any type of solar tracking system. The webcam is then connected to the USB port of the computer, in order to power up the webcam, and to develop a communication between them. A webcam has no built-in memory, so the communication is required, because the webcam will broadcast video images in real time and send them immediately to the computer.

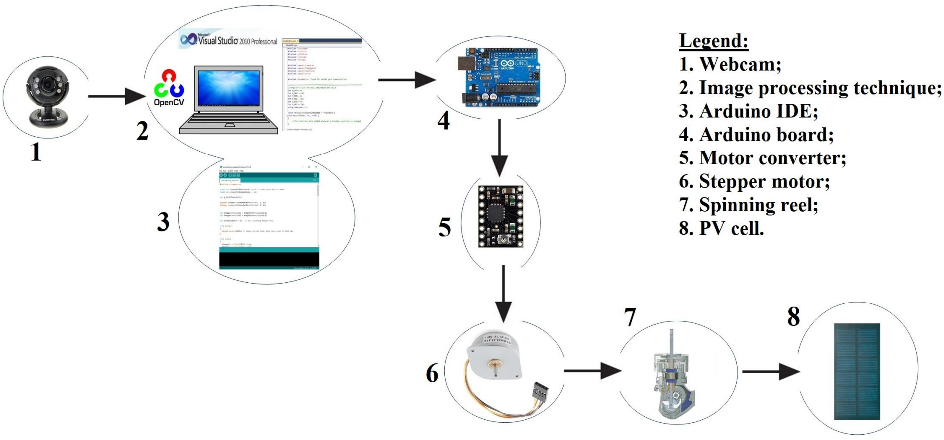



Fig. 4 − Design architecture of the solar tracking system.

The image frames captured by the webcam, must be processed in a software, to develop the Sun tracking technique. The whole imaging technique is developed in the C++ programming language, where all the tasks required to run the system smoothly are implemented. Nevertheless, this program developed ensures communication with the Arduino Uno board. Naturally the program receives the video frames from the webcam, and another window shows the processed image. In order to move the PV panel in the direction of the Sun, the information from the program will be sent through serial communication to the Arduino board. The Arduino board requires software implementation, in order to fulfill the tasks sent by the C++ program.

The software for the Arduino board contains the functions, which ensure the serial communication between the C++ program, and the tasks that will be sent to the stepper motors. Each stepper motor requires a driving circuit which features adjustable current limiting, over-current and over-temperature protection, and five different micro step resolutions. Using the drive circuit, the set-up will get maximum performance from the motors, and the control of the desired steps, and direction can be made. Each converter circuit requires a logic supply voltage to be connected to the microcontroller board, and a motor supply voltage, which in this case is the PV and a battery for the logic during the night DC power supply.

## 5. Hardware Setup

The tracking system is provided with a photovoltaic cell, mounted on a rigid support, in this experiment a plexiglass sheet, which has three supporting points. The main supporting point is the spherical bearing, which is attached to a threaded rod. The other two supporting parts are the spinning reels, which can move the panel manually by means of crank handles or automatically by image processing technique. Each spinning reel has a small wheel attached to it, and each wheel is attached to the shaft of the stepper motor. Each motor is mounted between two equally cut plexiglass sheet and screwed to the upper sheet and the one below the motors. The stepper motors are provided with electronic circuits, in order to control them by the Arduino microcontroller and to avoid any damages that can be caused to the motor.

The panel supporting the photovoltaic cell has a webcam mounted on it. The Arduino microcontroller is mounted on a separate sheet. The four-threaded rod holds each plexiglass sheet, besides the one that has the webcam and PV panel mounted. The complete hardware set-up can be seen in Fig. 5.

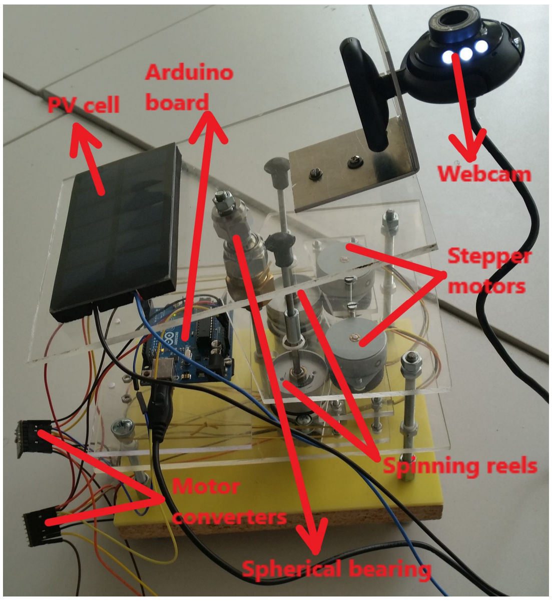



Fig. 5 – Hardware set-up.

The Arduino Uno used in this project is a microcontroller with a "ATmega328" processor. It has 14 digital input/output pins of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The board contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable, or power it with a AC-to-DC adapter or battery to get working with it.

The Uno board differs from all preceding versions in that it does not use the FTDI USB-to-serial converter chip but instead, it features the Atmega8U2 programmed as a USB-to-serial converter. The Arduino Uno can be powered with a USB cable or with an external power supply.

External non-USB power can come either from a PV voltage or battery. The integrated development environment (IDE) is an Arduino software which enables the possibility to program the microcontroller from the board. It offers basic functionality of other programing applications, also it offers a simulation mode which tests the program before uploading. It has the possibility to configure on what COM port the board is installed and automatically detects the type of the connected board. The converter used for the stepper motors A4988, is a micro stepping converter for controlling unipolar stepper motors which has built-in translator for easy operation.

This means that it can control a stepper motor with just 2 pins from the controller, in essence one for controlling the rotation direction and the other for controlling the steps. A webcam is a compact digital camera one can hook up to computer to broadcast video images in real time. Just like a digital camera, it captures light through a small lens at the front using a tiny grid of microscopic light-detectors built into an image-sensing microchip.

The image sensor and its circuitry convert the picture in front of the camera into digital format, a string of zeros and ones that a computer knows how to handle. Now in order to control the stepper motors, the wires were connected carefully from the converter and then to the stepper motor. The VDD and Ground pins that are needed to connect them to the PV cell and in parallel it was connected a capacitor and a battery in order to maintain the power for the converters.

The following 4 pins are for connecting the motor, the 1A and 1B pins will be connected to one coil of the motor and the 2A and 2B pins to the other coil of the motor. Decoupling capacitor was used with a capacity of 100 μF for protection against voltage spikes.

Fig. 6 represents the wiring of the components used in this research. μC is the Arduino microcontroller, C1 and C2 are the converters, C is the capacitor, $M1$ and $M2$ are the stepper motors, PV is the PV cell.

In order to control the steps of the motor, the wires were connected to the direction (DIR) port and the step pins of to the pins number 3 and 4 respectively pins number 5 and 6, on the Arduino Board and as well the two Ground and the 5 V respectively 3.3 V pins for powering the two converters.

The laptop must be always connected to the Arduino board, because the image processing technique is developed in the C++ programming language where the signals needed for the motors to act are then sent to the Arduino board.

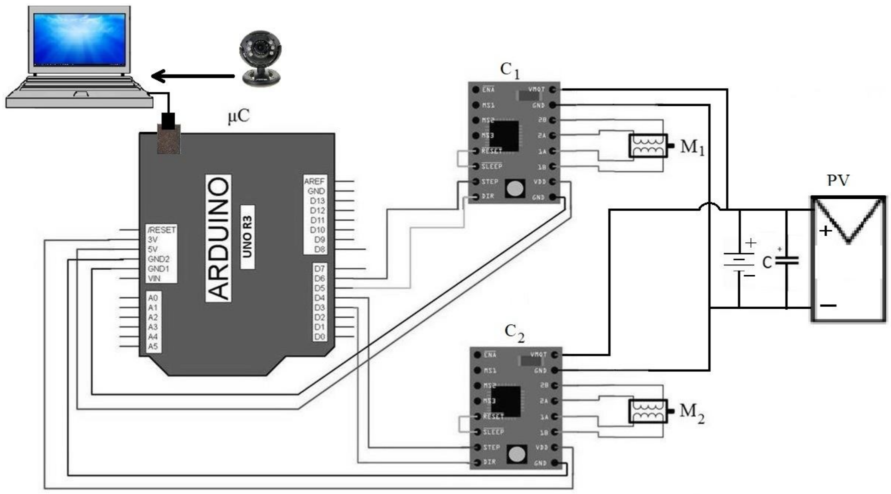
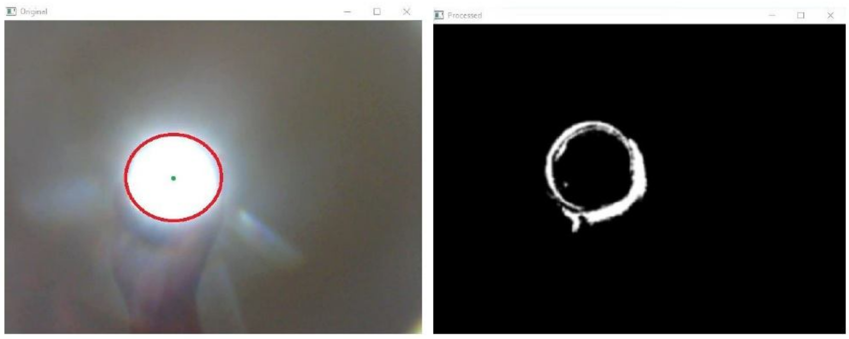



Fig. 6 − Wiring diagram of the setup.

## 6. Experimental Results

Two windows were created from the image processing, one being the original RGB color image (see Fig. 7 *a*) received from the webcam, and the other one is labeled as the processed window which is a conversion from RGB color to HSV color image (see Fig. 7 *b*). The color of any object in a digital photo is the combination of red-green-blue (RGB) color element. The webcam sending the video frame will have this combination of colors. Each pixel represented on an image stored in a computer has a pixel value which defines how bright and what color is the specific pixel. Considering the simplest case of a binary image, where the pixel value is a 1-bit number indicating the background or foreground. A common pixel format is the byte image and the value of this pixel is stored as an 8-bit integer having a range of possible values from 0 to 255. Zero is represented by a black color and 255 is white. Values in between are different color combinations.

HSV is another way to describe a color consisted of hue, described by a number that specifies the position of the corresponding pure color on the color cube, saturation giving the amount of chroma, more precisely it is a scale of how much of a pure hue is present and lightness or value is how bright the color is. The brightness in HSV coloring can be separated to make the colors less vulnerable to the impact of the light intensity, thereby affecting the Sun tracking system with noises The Gaussian filter also known as the Gaussian smoothing is used to blur the processed image in order to remove the noise that may appear on the image and any additional unnecessary details. When no webcam is connected to the computer an error message will appear notifying the absence of the device. It will be studied the acceptable level at which the tracker will detect the point with maximum irradiation.



*a* *b*

Fig. 7 – *a* – The original image captured; *b* – binary image processed.

After getting the binary image, it is necessary to find the shape of the sun image.

Communication with the Arduino board is necessary, because the stepper motors are connected to it, and they move according to the position of the sun depicted on the webcam. A serial communication was established with the Arduino board, and each time the software is started, it will check if the connection was successfully made. In order to get communication with the microcontroller, you must introduce in the programming code the communication port, which is connected to the Arduino. In case when no connection was made, the console will pop-up a window showing there is no connection with the port.

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The serial protocol has a number of rules that helps ensure error-free data transfer to the microcontroller, and it is configurable. Both devices on a serial bus are configured to use the exact same protocols. Some settings are required to implement in the program to ensure the communication, which are the following: baud rate: 9,600 bits per second, data size: 8 bit, no parity, stop bits: 1 stop bit.

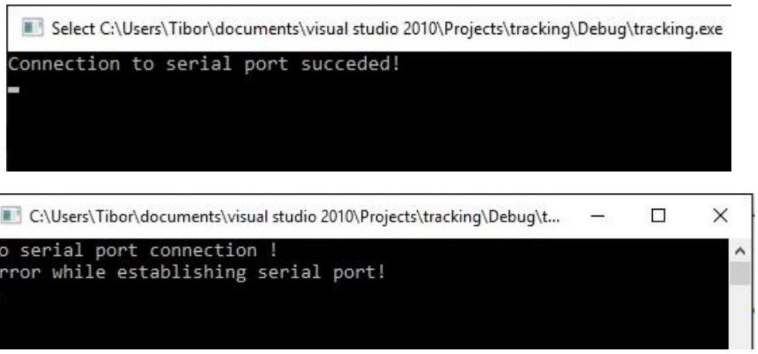
(a)
(b)



Fig. 8 – *a* – Port communication established ; *b* – no serial connection available.

## 7. Conclusion

The paper has presented a solution of tracking the sun's position with the help of a webcam and a microcontroller and it was cost effective. Taking into account the obtained results, one can conclude that the proposed solution for a solar tracking system offers several advantages concerning the movement command of the solar panel. Firstly, it has a favorable cost/performance ratio, which is achieved due to the simplicity of the adopted mechanical solution and the flexibility of the intelligent command strategy. Secondly, a minimum of energy consumption is obtained, due to the fact that the panel movement is carried out only in justified cases, eliminating unnecessary consumption of energy, and due to the cutting of the power circuit supply between the movement periods of the PV panel.

Based on the obtained results it can be affirmed that proposed solution is effective and presents interesting advantages from the point of view of practical applicability to larger power PV structures. The prototype has limitations regarding the maximum power that can be harnessed from the sun.

The tracking of the sun's position was an effective way to learn the benefits and working procedures of such a system. Still it provides an opportunity for improvement in future works such as to obtain the maximum amount of incident energy or the maximum amount of solar irradiation. There has been presented a methodology to forecast the short-term solar radiation, suitable for photovoltaic energy predictions (Alessandro, 2018). This short-term forecast of solar radiation allows estimating in advance the energy production of PV systems with a good accuracy. This methodology could be a part of a future improvement.

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## REFERENCES


Aashir W.A., Dr. K M Hassan B., Umar Siddique Virk C., *Designing a Dual Axis Solar Tracker for Optimum Power*, University of Engineering and Technology, Lahore, January 2014.

Alessandro A., Lorenzo B., Giansalvo C., Enrico Macii, Andrea A., Edoardo P., *Forecasting Short-Term Solar Radiation for Photovoltaic Energy Predictions*, 7th Conf. on Smart Cities and Green ICT Systems, Funchal, Madeira, Portugal, March 16 – 18, 2018.

Aurélio G.M., Delly O.F., Maury Martins de O.J., Sérgio Z., Aristides R., *Development of a Closed and Open Loop Solar Tracker Technology*, Acta Sci-Technol. Maringá, **39(2)**, 177-183 (2017).

Jeng-Nan J., Radharamanan R., *Design of a Solar Tracking System for Renewable Energy*, Proc. of 2014 Zone 1 Conf. of the American Society for Engineering Education (ASEE Zone 1).

Julian Chen C., *Physics of Solar Energy*, Hoboken, NJ: John Wiley & Sons, 2011.

Kausik C., Nisarga C., Bappadittya R., Pabitra K.N., *Design and Development Stepper Motor Position Control System Using Atmel 85c51 Microcontroller*, Internat. J. of Emerging Research in Management &Technology, **2(12)** 44-48 (2013).

Kok-Keong C., Chee-Woon W., *General Formula for On-Axis Sun-Tracking System*, Solar Collectors and Panels, Theory and Applications, Dr. Reccab Manyala (Ed.), InTech, 2010.

Matthew G., *16-Bit Automotive Applications Microcontroller Division, Quick Start for Beginners to Drive a Stepper Motor*, Freescale Semiconductor Application Note, AN2974 Rev. 1, 06/2005.

Natarajan M., Srinivas T., *Study on Solar Geometry with Tracking of Collector*, Applied Solar Energy, **51(4)**, 274–282 (2015).

Reston Condit, *Stepping Motors Fundamentals*, Microchip Technology Inc., 2004.

Summer L., Fritz C., Vincent C., William Der-Jenq L., Leo C., Ojo F. A., ErhNan C., Curtis L., Jeff L., Tim L., Jeffery S., Eve C., *Design, Operation, and Performance Evaluation of a Cable-Drawn Dual-Axis Solar Tracker Compared to a Fixed-Tilted System*, Big Sun Energy Technology Inc. Energy Science & Engineering published by Society of Chemical Industry and John Wiley & Sons Ltd., 2015.

Tanvir A.K.Md., Shahrear T.S.M., Rifat R., Shafiul A.S.M., *Design and Construction of an Automatic Solar Tracking System*, 6th Internat. Conf. on Electrical and Computer Engineering ICECE 2010, 18-20 December, 2010, Dhaka, Bangladesh, 326-329.

Ţopa I., Adrian D., Diaconu L., *Elemente de execuţie electrice*, Ed. MatrixRom, Braşov, Romania, 2005.

Tudorache T., Kreindler L., *Design of a Solar Tracker System for PV Power Plants*, Acta Polytech. Hung., **7(1)** 23-29 (2010).

* * * Advanced Micro Systems Inc, Precision Step Motor Control and Drive Products, *Stepper Motor System Basics (Rev. 5/2010)*, (http://www.stepcontrol.com/ pdf/step101.pdf).

## SISTEM DE ORIENTARE A PANOURILOR SOLARE ÎN SCOPUL ENERGIEI REGENERABILE

(Rezumat)

Sistemele fotovoltaice sunt utilizate de mai multe decenii. Cerințele majore de energie electrică şi schimbarea recentă a condițiilor de mediu, cum ar fi încălzirea globală, rezultă la necesitatea unei noi surse de energie care să fie mai ieftină şi mai durabilă, cu emisii reduse de carbon. Energia solară a oferit rezultate promițătoare în încercarea de a găsi soluția problemei menționate. Utilizarea energiei solare folosind modulele fotovoltaice vine cu propriile sale probleme care apar din schimbarea condițiilor de iradiere. Aceste schimbări ale condițiilor de iradiere afectează eficiența şi puterea generată a modulelor fotovoltaice. Cantitatea de energie solară captată de un panou solar determină puterea generată pentru aplicațiile termice sau fotovoltaice. Sistemele de urmărire solare au un rol important în realizarea tehnologiilor de colectare a energiei solare. Lucrarea propusă este concepută pentru a detecta prezența soarelui şi poate poziționa panoul solar spre direcția soarelui utilizând sistemul de urmărire în două axe. Acest sistem roteşte panoul în funcție de poziția soarelui, astfel încât energia solară să poată fi utilizată eficient.