Smart Blinding Stick with Holes,Obstacles and Ponds Detector Based on Microcontroller

Mohammed Azher Therib
Al-Furat Al-Awsat Technical University/ Engineering Technical College of Al-Najaf
mohammedtherib@gmail.com

Abstract:

In this work, a device is designed and implemented that it is doing three jobs in order to help blind people to walk without accidents may occur. The first proposed one is accomplished by putting the ultrasonic sensor in a measured angle about 40^{o} on a suitable blinding stick to detect if there is a hole or stair in front of blind at about 48 cm distance to prevent him from falling and as a result may be causing many injuries.

The second one uses a moisture sensor in the first leg of the four legs stick to measure the degree of the land soil moisture in front of the blind and alert him when that degree exceeds a measured level that may immerse the feet of him. While, the third one is made by using another ultrasonic sensor on the stick to turn an alarm ON when there is an obstacle, person, or wall at a small distance about 50 cm near him to prevent a collision accident.

The stick is implemented practically using four leg blinding cane, Arduino microcontroller and the three sensors. Also, the three buzzers and one vibrator motor and three LEDs are used on the stick to turn on when a such problems occur. The device gives good results when many visually impaired people in Merjan medical city in Babylon used it.

Keywords: blinding stick, ultrasonic sensor, moisture sensor, Arduino microcontroller, alarm buzzers, vibrator motor.

الخلاصة:

في هذا العمل، تم تصميم وتنفيذ جهاز بثلاث خصائص لمساعدة المكفوفين على المشي دون حوادث ممكن أن تحدث. يتم إنجاز أول عمل يقوم به الجهاز من خلال وضع متحسس استشعار بالموجات فوق الصوتية في زاوية معلومة حوالي 40^{o} على عصا عمى معينة للكشف عما إذا كان هناك حفرة أو سلم أمام المكفوف بحوالي 48 سم لمنعه من السقوط، ونتيجة لذلك ربما تسبب إصابات عديدة.

أما الخاصية الثانية فتم استخدام متحسس استشعار الرطوبة في القدم الأولى من العصا الرباعية الأقدام لقياس درجة رطوبة الأرض أمام المكفوفين وتنبهه عندما تتجاوز درجة الرطوبة حدا معينا الذي عندما تتجاوزه قد تغطس أقدام المكفوفين في الأرض. وبالإضافة إلى ذلك، بينما تم إجراء الخاصية الثالثة باستخدام متحسس استشعار بالموجات فوق الصوتية آخر على العصا لتنبيه الأعمى أن كانت هناك عقبة، شخص، أو جدار على مسافة صغيرة حوالي 50 سم أمامه لمنع وقوع حادث تصادم.

تم تنفيذ هذه الخصائص عمليا باستخدام عصا عمى رباعية الأقدام، متحكم آردوينو، وأجهزة الاستشعار الثلاثة. أيضا، تم استخدام ثلاثة صفارات ومحرك هزاز واحد وثلاثة مصابيح باعثة للضوء على ذات العصا لتشغيلها عندما تحدث مثل هذه المشاكل. النظام المقترح كله أعطى نتائج جيدة عندما تم استخدامه من قبل العديد من المكفوفين في مدينة مرجان الطبية في مدينة بابل.

كلمات مفتاحية:عصا عمى، متحسس استشعار بالموجات فوق الصوتية، متحسس استشعار الرطوبة، مسيطر آردوينو، صفارات تنبيه، محرك هزاز.

1. Introduction:

Vision is the most important part of human physiology as 83% of human information being gets from the environment is via sight. There is a significant increase in cases of blindness in the world in general. The statistics by the World Health Organization (WHO) estimate that there are 285 billion people in world with visual impairment, 39 billion of which are blind and 246 with low vision (Dambhare and Sakhare, 2011). The majority of people with poor vision are in the developing world and are over the age of 50 years and about 90% of the world's visually impaired live in developing countries.

Iraq is a particular case of this problem according to terrorist operations and birth defects in newborns because of water and food contamination. Therefore, and since the science and technology always try to make human life easier, there was a great need for the means to help the visually impaired people to live without problems related to walking in homes, public roads or any other place**.**

Even for the non-visually impaired, the congestion of obstacles is sometimes problematic, it is even worse for the visually impaired. People with visual disabilities or blinds are often depend on external assistance like trained dogs, humans, or special electronic devices as support systems for decision-making.

Existing devices are able to detect and recognize objects that emerge on the floor, but a considerable risk is also includes the objects that are at a sudden depth, or obstacles above waist level or stairs(Sheth.*et.al.*,2014). The most widely used stick is the long cane because it can feel the nature of the path and detect obstacles in the path of the blind person (Agarwal *et.al.*, 2015).

The first study is at 2011 by Shruti Dambhare and A.Sakhare, which presents a theoretical model and a system concept to provide a smart electronic aid for blind people. The system is intended to provide overall measures artificial vision and object detection. The other papers add some techniques to develop the work of this study and some of them were listed in the following.

The main purpose of the other new researchers is based on abating the disabilities of blindness by constructing a microcontroller based automated hardware that can corroborate a blind to detect obstacles in front of him/her instantly (Mohammad *et.al*.,2013).

RF transceiver simulator is used by(Pushpa *et.al*.,2015) to provide the traffic signal information for pedestrian crossing in real time scenario and also the bus route information to help the user know about the desired bus.

There is one more advantage of another system (Abhishek *et.al*, 2016)that is sometimes when the blind loose there sticks or forgot where they have put it, they can find it by using the wireless remote. In addition, the blind stick is integrated with ultrasonic sensor along with water sensing using moisture sensor (Vipul *et.a.*,2016).

Being an emerging area of research, Motivations of the work are presented in Section 2. The proposed smart blinding walking stick and discussion of its parts is explained in section 3. Results of the practical test is discussed in section 4. Conclusions from the research is shown in section 5. Suggestions for future work are listed in section 6. Finally, References of the paper in section 7.

2. Motivations:

In this work, most of the problems that may face the blind people are solved like the barriers or people in front of him at a certain distance because they may cause a collision. The other problem is due to the presence of ponds that may immerse the feet of the blind in it and cause injuries too. In addition, holes or stairs in the way of the blind that will cause him to fall are another problem. Here the solutions to these problems are made and it differs from the others by the following points:

The first one is that previous studies did not solve the existence of a hole in front of the blind, causing fractures in the bones or other injuries that will studied in this work.

While, **the second one** is that all scenarios implemented practically and gave good results in addition to previous theoretical or simulated studies.

3. Proposed Smart Blinding Stick System:

The proposed system that implemented in this paper is shown in figure 1. It consists of Arduino microcontroller, two ultrasonic sensors, one for obstacles and other for holes detection. The moisture sensor for ponds detection process and vibrator motor are also used for alerting the blind in addition to three buzzers and LEDs for the same purpose.

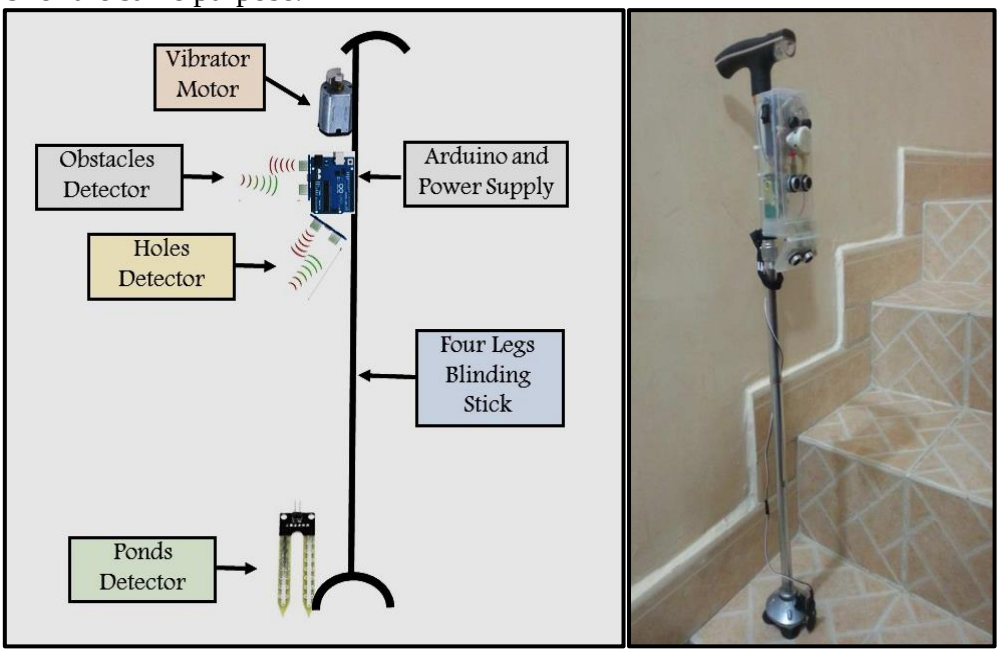


Figure 1 Proposed Smart Blinding Stick System.

Any control system has three steps in general: sensing, controlling and then actuating process. The proposed control system that is used in this work is shown in figure 2 where these three steps are explained.

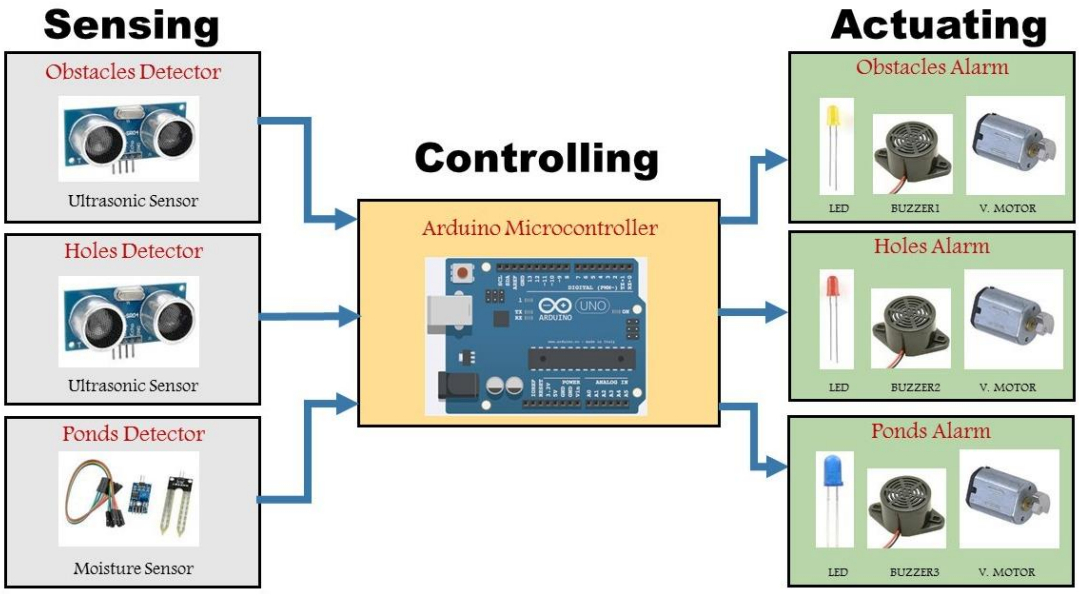


Figure 2 Proposed Control System.

Figure 3 shows the flowchart of the proposed smart stick system for each step that the blind walking. It also shows the sensors' and actuators' work and the control process that done by Arduino UNO.

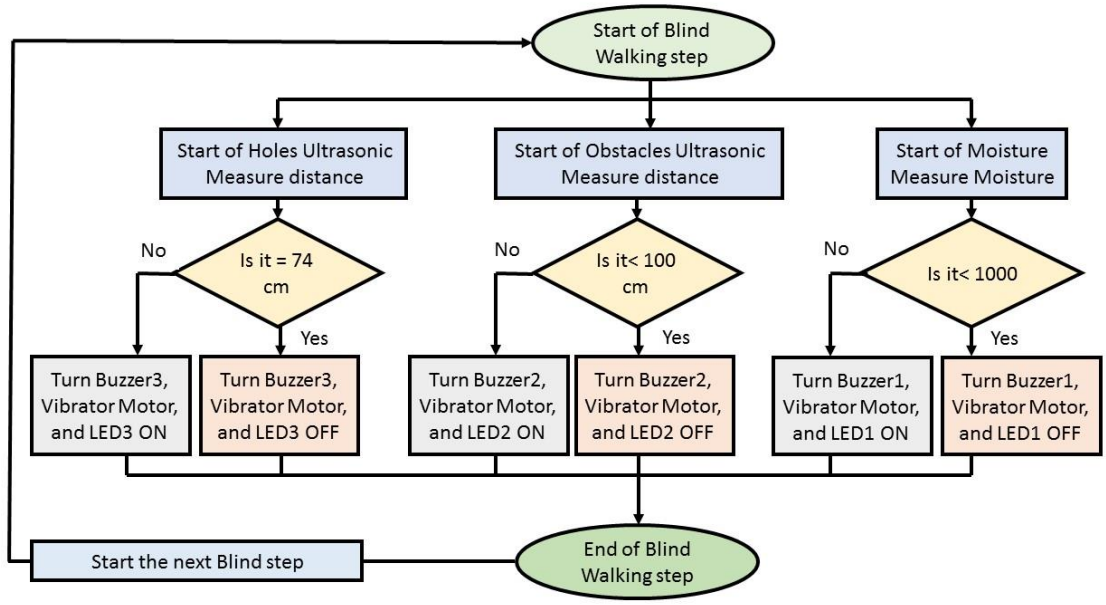


Figure 3 The flowchart of the work of proposed system.

The proposed system has many functions and consists from a number of parts and scenarios. The following sub-sections will deal with these parts and functions and explain them with details:

3.1 Obstacles Detection:

Small low-cost ultrasonic distance measurement modules like SRF-06 are an effective ways to sense the presence of nearby objects and the distance to them. Often Robots use these to sense objects or collisions and take appropriate action.

Ultrasound is a high frequency sound (typically, 40 KHz is used). A short burst of sound waves (often only 8 cycles) is sent out the "Transmit" transducer (left, above). Then the "Receive" transducer listens for an echo. Thus, the principle of ultrasonic distance measurement is the same as with Radio-based radar. It emits an ultrasound at 40 000 Hz, which travels through the air as shown in figure 4 and if there is an object or obstacle in its path It will bounce back to the module. Considering the travel time and the speed of the sound, you can calculate the distance.

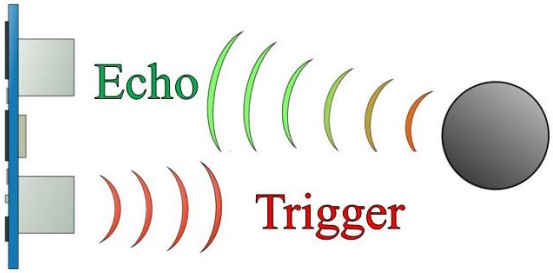


Figure 4 Ultrasonic sensor work

The air density affects speed of sound in air velocity, and for high accuracy, the temperature must be taken into account, either within the module electronics (In the SRF-06 module we have) or in the Arduino software.

When someone or barrier reaches near the blind by less than 1 meter (100 Cm in the Arduino C language code), the series of beep sound from the buzzer1 and the vibration from the motor will alert the blind. Also, the yellow LED will turn ON to alert the person in front of the stick as shown in figure 5 when the stick faces the wall in some centimeters.

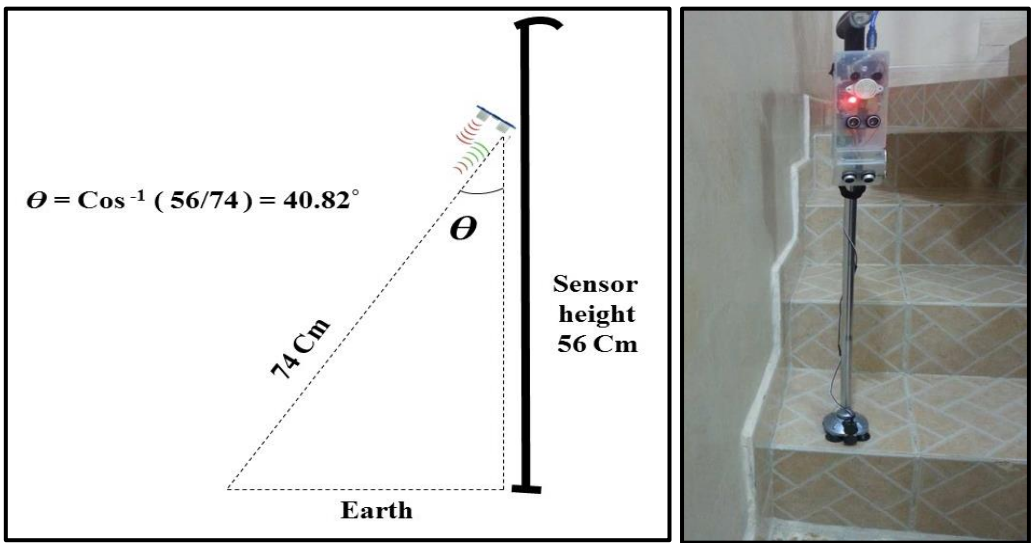
Figure 5 Obstacles Detection.

3.2 Holes Detection Process:

The algorithm that proposed in this work to detect the holes was made by using ultrasonic sensor (that discussed in the obstacles detection process) put on the stick at a slope by an angle of about (40°). Thus, if the sensor is put at a height of 56 Cm, the distance of the sensor (depends on the Cosine law) should not be higher than 74 Cm to show that there is no any hole in the road.

If the measured distance at the end of the stick step succeed that level, that means the next step must be dangerous and the sensor will alert the blind by many ways. Sound is one of these ways using one of the used buzzers that different from the others by sound of beeps that recognized by the blind. The other way, is by sense using vibrating motor putted on the stick in addition to the red LED.

Figure 6 (a) shows the principle of the process depending on the place of ultrasonic sensor on the stick to detect the holes and angle measurement, also the practical implementation is shown in the second picture. Note that in all practical implementations of the three cases, Arduino turned one of the buzzers in addition to the vibrating motor to ON state.



(*a*) **(*b*)**

Figure 6 Holes Detection Process and angle measurement.

3.3 Ponds Detection Process:

In order to detect the ponds or wet areas of soil, the moisture sensor was put in the forward leg of stick to show the degree of moisture of earth soil to prevent immersing in the mud. In addition, the four legs stick must be used because all the sensors must read the values properly by making the stick in 90° angle on the earth.

Soil moisture sensor that is shown in figure 7 measures the volumetric water content in soil. Since the direct gravimetric measurement of free soil moisture requires removing, drying, and weighting of a sample, soil moisture sensors measure the volumetric water content indirectly by using some other property of the soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content.

The relation between the measured property and soil moisture must be calibrated and may vary depending on environmental factors such as soil type, temperature, or electric conductivity. Reflected microwave radiation is affected by the soil moisture and is used for remote sensing in hydrology and agriculture.

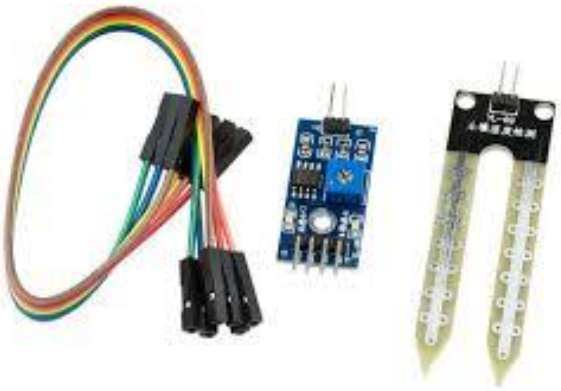


Figure 7 Moisture Sensor.

The moisture sensor is used in proposed system to read the degree of soil moisture degree. In the first step, It turns the buzzer3, vibrating motor, and blue LED to ON state when the reading exceeds 1000 as shown in figure 8. While, it turns them to OFF state in the other degrees.

Figure 8 Ponds and wet soil detection process.

3.4 Arduino Microcontroller:

The Arduino (shown in figure 9) is used to process the data coming from the sensors. It is programmed to control the unit tasks receives data from the sensors, processing and sending orders to the used actuators for the purpose of control of the stick. The processor subunit used in this system is the Atmel MCU (ATmega328), the Arduino platform that contains the ATmega328 MCU is used and this platform is the open source platform, which is easy to use in terms of software and hardware. The most important specifications of the MCU are (Therib, 2015):

Digital I/O	14 Pin
Analog Input	6 Pin (10-bits ADC)
DC Current per I/O	40 mA
Flash Memory	32 KB (ATmega328)
Clock Speed	16 MHz

MCU is programmed through the Arduino programming language, which is integrated development environment (IDE). This language based on C / C + + language. The MCU was programmed to control the unit tasks and receives data from the three sensors, processing this data and sending orders to the buzzers, LEDs and the vibrating motor in order to alert the blind when it is necessary.

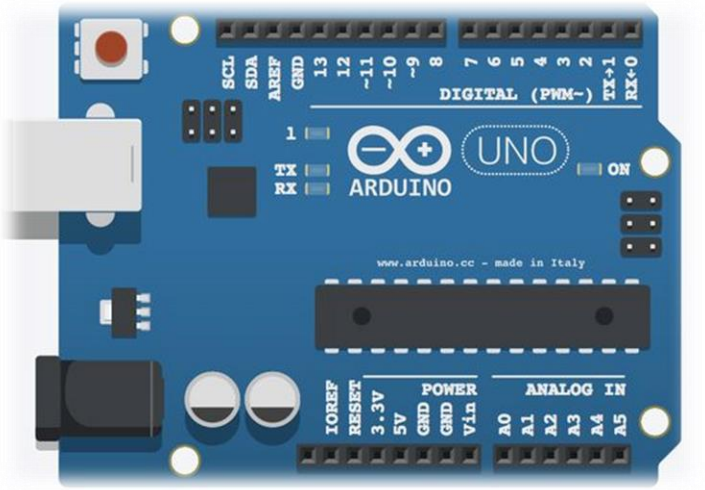


Figure 9 Arduino UNO.

3.5 Vibrating Motor:

Eccentric Rotating Mass vibration motors, also commonly known as ERMs or pager motors as shown in figure 10, make up the main product lines and have been the core business since Precision Micro-drives was founded.

They shot to popularity used in pagers and have grown alongside the mobile/cell phone industry, where they are still extremely popular in smartphones. Now there are a wide range of applications that use these tiny vibration motors to offer vibration alert notifications and haptic feedback. Miniature DC vibration motors has the benefit of being easy to implement and are low cost, whilst dramatically augmenting how devices interact with users.

Figure 10 Vibrating Motor.

3.6 Buzzer

The Piezo buzzer (shown in figure 11) produces sound based on reverse of the piezoelectric effect. The generation of pressure variation or strain by the application of an electric potential across a piezoelectric material is the underlying principle. These buzzers can be used to alert a user of an event corresponding to a switching action, counter signal or sensor input. They were used in proposed circuit to alert the blinds by using sound (Deshpande *et.al.*,2016).

Figure 11 Used buzzers.

The buzzer produces a same noisy sound irrespective of the voltage variation applied to it. It consists of piezo crystals between two conductors. When a potential is applied across these crystals, they push on one conductor and pull on the other. Thus, push and pull action, results in a sound wave. Most buzzers produce sound in the range 2 to 4 kHz (Deshpande *et.al.*,2016).

4. Results:

The proposed smart blinding walking stick gives good results when the doctors of Merjan medical city in Babylon city examined it with many visually impaired and blind people that came to the hospital for treatment. Many tests failed to give the expected results while the others give excellent results especially with the obstacles detector tests.

Table 1 shows the number of the tests and the number and percentage of the succeeded tests on the blinds in the hospital. In addition, the measured distance of holes and obstacles and the soil moisture degree when the device is implemented is also explained.

Table 1 number and percentage of practical and succeeded tests

Device Jobs	Number of tests	Measured degrees	Number of succeeded tests	Percentage of succeed tests
Holes	16	46.5 Cm	12	75%
Obstacles	16	0.5 Cm	16	100%
Ponds	12	1000	10	83.33%
Average percentage of succeed of the tested device				86.11%

5. Conclusions:

The main target of this project is to assist blind or visually impaired people to safely-move among obstacles, holes, ponds and other hurdles faced by them in their daily life. The solution developed is a user-friendly navigational aid for them. The advantage of the system lies in the fact that it can prove to be a very low cost solution to millions of blind people worldwide.

The aimed combination of several working sub-systems makes a time demanding system that monitors the environmental scenario of static and dynamic objects and provides necessary feedback forming navigation more precise, safe and secure.

6. Future Works:

1- Increasing the number of sensors and actuators to implement some another applications like on-coming vehicle detection, fire or smoke.
2- The global positioning system GPS can be added to the device.
3- GSM and cameras system can be also implemented.
4- Caps or jackets as alternative tools to the stick can be used to help the blinds.

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