Arduino Uno based Smart Cane for Osteoarthritis patients

Gautam Singh[#1], Sarvesh Srivastsva[*2], Gautam Gupta[#3], Prof. A. B. Patil [#4]

[#]*Students of Department of Electronics and Telecommunication*

Bharati Vidyapeeth (deemed to be University) College of Engineering, Pune Katraj, Pune (Maharashtra), India

[1] gautamks297@gmail.com

[2] gautam.37510@gmail.com

[3] sarveshsrivastava51@gmail.com

[4]abpatil@bvucoep.edu.in

Abstract *— With the help of this project on Smart Cane we are developing a cane which will be useful for the patients of the osteoarthritis so that their knees will be less wear and tear while walking, since in the condition of arthritis it is necessary for the patients to walk regularly but due to severe pain they are not able to walk much which led them in the condition of stagnation. With the help of our smart cane user will get notified of the number of the number of steps he/she can walk without having wear and tear of his/her knees. Arthritis is the swelling and stiffness of joints. It can occur in one or more of your joints. The main symptoms of arthritis are joint pain, swelling and reduced range of motion. The most basic types of arthritis are osteoarthritis (OA) and rheumatoid arthritis (RA). Osteoarthritis causes cartilage — the hard, slippery tissue that wraps the ends of bones where they form a joint — to fall apart. Rheumatoid arthritis is a condition in which the immune system attacks the joints, beginning with the wearing of joints. Uric acid crystals, which form when there is a lot of uric acid in your blood, which can cause gout. Infections or underlying disease, such as psoriasis or lupus, also other types of arthritis.*

Osteoarthritis, the most natural form of arthritis, which involves the wearing away of the tissues that caps the bones in your joints. With rheumatoid arthritis, the synovial membrane that protects and lubricates joints becomes inflamed, causing pain and stiffness. Joint erosion may also occur.

Keywords — *Osteoarthritis(OA),Body Mass Index(BMI), Rheumatoid arthritis (RA),Integrated Development Environment (IDE),Multicentre Osteoarthritis Study(MOST)*

I. INTRODUCTION

Knee osteoarthritis (OA) is a highly predominant condition affecting approximately 24% of the world's population and has a lifetime danger of almost 1 in 2. Severe pain and physical dysfunction are hallmarks of knee osteoarthritis. Given that there is no cure for this dreadful condition, treatments that emphasize self-assessment are preferred. Although limited, current evidence supports the use of a walking cane to reduce pain, improve physical function, and improve mediolateral knee stress distribution in people with knee OA. Indeed, stick use is advised by clinical guidelines as an accompaniment to core treatments of exercise and weight loss. Literature on aiding devices has greatly focused on their use in elderly populations. This literature often focuses on the stigma associated with aiding device use and the connotations that dependable devices carry about being old or weak. Older populations have described minimising falls as a prompting factor for using a walking stick or cane. In Parkinson's disease, cane use has been linked with poorer balance. There is much less literature identifying the use of aiding technologies, specifically walking canes, in a population with knee pain where the primary perspective is more often to reduce pain and boost physical function, rather than enhance balance. Although walking canes are recommended by clinical guidelines for knee OA, use of a walking cane is reportedly an underestimated self-management strategy in people with knee OA. There has been limited investigation into the grounds that influence whether patients with knee pain use, or do not use, a cane.

Some proofs suggest that older age, more extreme symptoms, and black race are associated with the utilisation of a walking cane in people with rheumatoid arthritis (RA) or hip/knee OA. The job of psychological factors in influencing cane behaviour has also been demonstrated in people with various arthritic conditions. A research by van der Esch et al showed that use of a walking cane in people with RA or OA of the hip or knee was associated with a more positive assessment of the aid, meaning that people who viewed walking aids more positively were more likely to use it. According to the Theory of Planned Behaviour, people will have a

greater motivation to use a cane if they have a more positive attitude toward utilizing a cane and face lesser difficulties in using a cane (greater perceived behavioural control). Capability, opportunity, and motivation are exceptionally significant impacts on behaviour. Motivation may be internal, relating to the personal level of problem associated with their symptoms, or external, such as advice to use a gait aid from a clinician or family member. Literature on the use of mobility aids in older people has found that physician encouragement is a strong motivating factor for use. No exploration to date has asked individuals with knee OA which factors are the most essential to encourage regular cane use. Further research to better understand determinants and facilitators of cane use is needed to distinguish target groups and facilitate the development and implementation of strategies aiming to promote cane use, explicitly among individuals with knee OA. We therefore conducted a survey of adults with knee OA to investigate demographic, symptom-related, and cognitive (attitudes and perceived behavioural control) determinants of cane use, and to prioritize factors that could encourage regular cane use in individuals with no previous cane use.

PROBLEM STATEMENT

Normal cane can be only used for walking and balancing purposes and to take support while walking. It cannot perform many tasks like:-

1) Measuring the number of steps walked by the user.
2) Identifying whether the user is maintaining correct posture or not.
3) Identifying whether the angle of incidence of the cane is correct or not.

With the help of electronics and biotechnology the standard cane be evolved to a great extent. As in our case we tried to increase the usability of the standard cane and converted it to a smart cane.

II. COMPARATIVE TECHNOLOGY

Walking problems are abnormalities and issues that linger from person to person. These problems have several possible factors affecting not just the feet and legs but also the brain, muscles, ears, eyes, and spinal cord, among others. Problems with walking manifest in different types, such as those affecting the gait, balance, and many others. The good news is there are available solutions and strategies that can either resolve a walking issue or help a person accustomed to the condition.

A. Normal Cane

A mobile cane or walking cane is a device used basically to aid walking, providing functional dependability or backing, or help with keeping up a decent stance.

The right cane improves balance and minimises the risk of falling by expanding the base of support, as well as decreasing weight on lower-body joints.

Usage of cane may reduce risk of Osteoarthritis progression.

Walking sticks come in various shapes and sizes and some have become collector's items. People with disabilities may use some kinds of walking sticks as a prop. The walking stick has also historically been known to be used as a protective or hostile weapon and may conceal a knife or sword – as in a swordstick.

Usage of normal cane:-

The patient stands easily erect (in low-heeled shoes), with arms loose close to the body. The cane is then placed with the tip on the floor, 10 cm from the lateral margin of the ankle (in line with the metatarsals). To accomplish an elbow flexion angle somewhere between 20° and 30°, the cane height adjusted to reach the distal fold of the wrist (wooden canes are marked to this height and cut).
Ideal height of a standard walking cane should be approximately equal to half the height of the user.

B. Smart Cane

The smart cane will be used for all conditions in which a cane was required and its force-measuring abilities were activated throughout the process. The cane require the BMI of the user as the input and according to the load exerted on the stick the user will get the max no of steps/distance user can cover. The cane will protect the user for further wear and tear of his joints. It will also be provided with GPS and GSM module which will track the user's location and when user will be in trouble he/she can send his/her current location and message to users family or relatives using the SOS button attached in the cane. The smart cane was a standard Aluminium cane fitted with a load cell at the handle of the cane.
The BMI of the user is provided as input by the patient.According to the BMI and Force exerted on the cane by the user it will display no of steps/distance can be covered by the user without further damage of joints. If the provided input and force exceeds a certain limit, the cane will display the user is not suitable for walking.

Comparison between standard and smart cane

1) A normal cane is just a regular stick with a handle attached to it, while the smart cane is high-tech cane equipped with the latest technology.
2) A normal cane only helps the user to walk through applying load on the cane but the smart cane helps the user in other ways as in providing number of steps , emergency contact feature etc.

3) The normal cane cannot be upgraded it will remain as it is but the smart cane can be upgraded with new features as per the use.
4) The smart can be adjusted for each and every user as it takes the user personal health details like BMI , knee pain etc., while the normal cane is non-adjustable.

III.SCOPE OF THE PROJECT

This main scope of the project is in the medical field for the patients suffering from the lower joint disorder or any kind of problem while walking.
The Smart Cane will help the patients in many ways:
1. It will provide the support they need while walking.
2. Helps in the correction of body posture.
3. Helps to stop the progression of their arthritis condition by displaying them the max distance they can cover without hurting their knees.

IV.ADVANTAGES

The advantages of the Smart Cane were as follows:
1. The progression of the patient condition can be stopped or controlled.
2. The real time monitoring of the patient can be achieved.
3. The smart cane can provide the approximate number of steps to the user for walking based on the input.
4. In case of emergency the patient can send their location as well as an emergency message to the family.

V. DISADVANTAGE

The disadvantages of the Cane were as follows:

1. The data provided were based on a survey which is efficient for majority of the users, but it can be not very useful for some patients as it is not a universal thing.
2. Efficiency of the stick also depends on the user.
3. Stick can be used by multiple patients only after providing their BMI as an input to the system.
4. The cane does not calculates the number of steps travelled.

VI. SYSTEM IMPLEMENTATION

The main objective of our project work is to develop a model which allows customer to ensure the safety of the patient and real time monitoring of the user.
It is mainly developed for the patients of arthritis.
For the arthritis patient who require a stick for acquiring the correct posture for their body. For the obesity patient it really helps in reducing the risk of the weight gain which further reduces the risk of progression of their condition. Usage of cane may reduce risk of Osteoarthritis progression.

Circuit Diagram

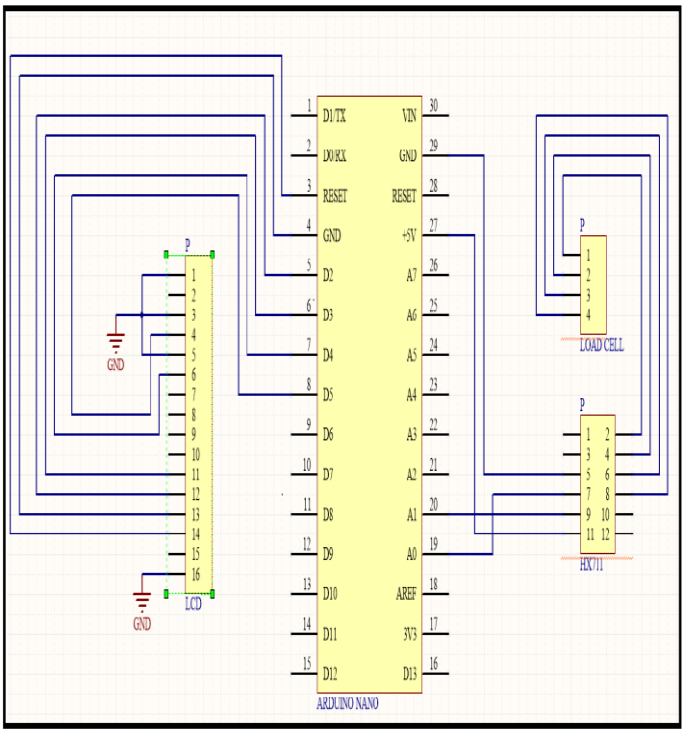

Fig. 6.1 Circuit diagram

Principle of working

The principle of smart cane is to measure the load exerted by the user on the joints and provide the data accordingly. The load on the joint is measured using the load cell which is placed on the stick. The load is measured and accordingly the data will be provided to the user for the maximum amount of steps the user should walk.

Functional working

The load cell will be attached to the handle of the standard cane. The cane has 2 inputs, first input will be in the form of BMI of the user and then second input will be will be taken as load from the user through the load cell.
The Arduino Uno is working as the centre processor in the project. The programming code written in C language is fed into the Arduino. The 16x2 LCD is connected to the Arduino. The number of steps are displayed in the lcd. The BMI of the user will be given as input via the arduino through the software. The load cell takes the load applied by the user, load taken will be forwarded to HX711 which the weight sensing module connected to both load cell and arduino uno. The HX711 acts as a connecting medium between load cell and arduino. The HX711 module transfer the signal to the arduino. The arduino analyses and calibrates the signal to the standard format. Both the GSM and GPS module are also connected to arduino, code for both the module are also implemented into the arduino.

SYSTEM FLOWCHART

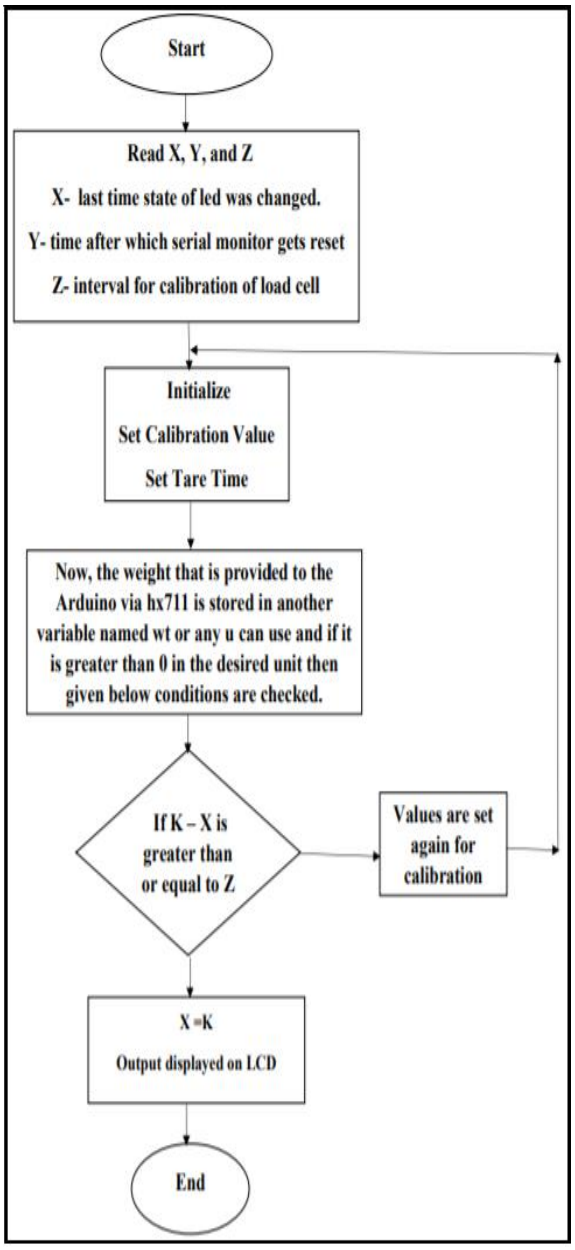

Fig 6.2 System Flowchart

Load Cell

A load cell is a transducer that measures force, and outputs this force as an electrical signal. Here we have used Single point shear beam load cell. In which spring element fixed at one end and load of force is exerted on the other end.

Fig.6.3 Load cell

And the load capacity of the load cell used is 20 kg. Most of the load cell uses the method of strain gauge as they convert the force acting of them into electrical signal and then display it digitally on the LCD using the Hx711 weight sensing module.

Specifications of load cell:
Weight capacity max: 20 kg
Maximum overload : 24 kg
Zero balance : ±300 g
Controlled by : Bridge input

SOFTWARE IMPLEMENTATION

Arduino IDE

The open-source Arduino Software (IDE) makes it simple to compose code and transfer to the board. This product can be utilized with any of the arduino sheets. It can run on any of the working framework like Windows, Linux, MacOS and so forth. The code can be written in the vast majority of the programming dialects, which makes the product very adaptable. A program for Arduino might be written in any programming language for a compiler that produces twofold machine code for the objective processor. Atmel gives an improvement situation to their microcontrollers. The Arduino venture gives the Arduino coordinated improvement condition (IDE), which is a cross-stage application written in the programming language Java. It incorporates a code manager with highlights, for example, content reordering, looking and supplanting content, programmed indenting, support coordinating, and sentence structure featuring, and gives basic a single tick instruments to aggregate and transfer projects to an Arduino board. It additionally contains a message territory, a book comfort, a toolbar with catches for basic capacities and a progressive system of activity menus. A program composed with the IDE for Arduino is known as a sketch. The Arduino IDE bolsters the dialects C and C++ utilizing unique standards of code organizing. The Arduino IDE supplies a product library from the Wiring venture, which gives numerous basic info and yield procedures.This program utilizes the capacities pinMode(), digitalWrite(), and postponement(), which are given by the inner libraries remembered for the IDE condition. The program is normally stacked in the Arduino by the producer.

VII. RESULT TABLE

BMI	N1UMBER OF STEPS	REDUCED STEPS RANGE (when load is applied)
<25 (Healthy)	7073	(6096-3733)
25-27 (Overweight)	6532	(6365-3232)
28-30 (Overweight)	5636	(5469-2316)
31-33 (Obese class 1)	5474	(5307-2154)
33-35 (Obese class 1)	4533	(4366-1213)
>35 (Obese class 2)	3718	(3552-416)

Table.7.1

For increase in every per kilogram load there will be decrease of 167 steps for the user.

Performance Table:

Parameter	Standard walking cane	Proposed Smart cane
Success Rate	20-30%	55-75%
Accuracy of Prediction	-	85-88%
Test duration for single test	10 minutes	15 minutes
Cost	800/-	7000/-

Table. 7.2

The values in the performance table for standard cane are obtained with the help of reference 11and 12 in the references section and the values of the smart cane are obtained through repetitive experimentation and approximation with respect to standard cane.

Limitations of the cane:

1) The cane is specific per user as the BMI differs from person to person.
2) The load limit of the cane is 20 kilograms it cannot measure load beyond it.
3) It uses a battery for its power supply so the battery needs to be charged regularly.
4) The steps mentioned in the result table can be useful to people with arthritis or at a risk of arthritis.

System Cost

The overall project cost has been estimated taking into account the various other costs that had been encountered en-routed to development of the project. This includes the cost of components and necessary equipment required for combining the project i.e. Soldering iron, PCB board and the overall cost of the project is around 7000 INR.

Power Consumption

The power source used in this model is a batter of 18 V. Instead of using a battery a power bank of 10000 mAh(milli-Ampere hour) power can also be used.

VIII. CONCLUSION

The major achievement of the project is to provide stability to the user by monitoring the condition of his joints and providing the effective data for the user such that the condition of his arthritis should not be worsen.

The real time monitoring of the patient is also done by using the GSM and GPS module as in the case of emergency the patient can be traced easily by his family members or caretakers.

IX. DEVICE PHOTO

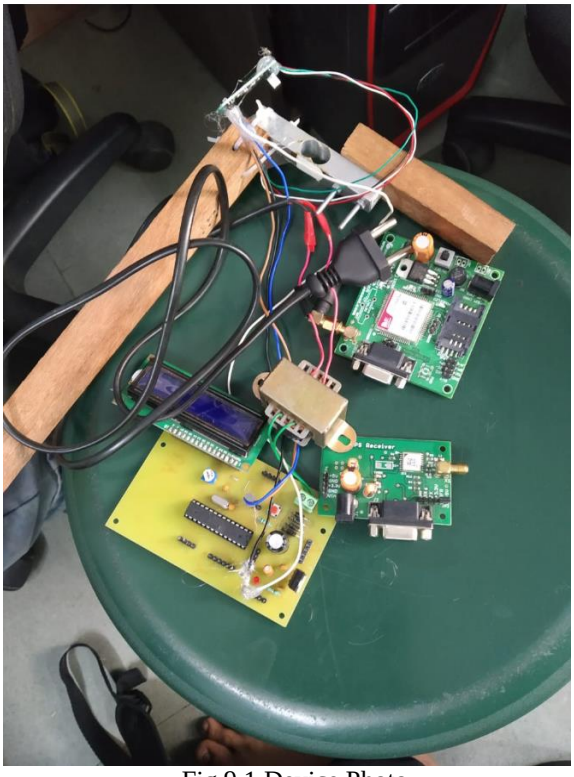

Fig.9.1 Device Photo

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X. REFERENCES

1) Jones A, Silva PG, Colucci M, Tuffanin A, Jardim JR, Natour J. Impact of cane use on pain, function, general health and energy expenditure during gait in patients with knee osteoarthritis: a randomised controlled trial. Ann Rheum Dis. 2012; 71: 172–79. (http:// www.ncbi.nlm.nih.gov/pubmed/22128081).

2) Routson RL, Bailey M, Pumford I, Czerniecki JM, Aubin PM. A smart cane with vibrotactile biofeedback improves cane loading for people with knee osteoarthritis [abstract]. Conf Proc IEEE Eng Med Biol Soc 1:3370–3.

3) Jiang L, Tian W, Wang Y, Rong J, Bao C, Liu Y, et al. Body mass index and susceptibility to knee osteoarthritis: a systematic review and meta-analysis. Joint Bone Spine. 2012

4) Reijman M, Pols HA, Bergink AP, Hazes JM, Belo JN, Lievense AM, et al. Body mass index associated with onset and progression of osteoarthritis of the knee but not of the hip: the Rotterdam Study. Ann Rheum Dis, 2007.

5) KA Theis and L Murphy of the Centers for Disease Control and Prevention (CDC) Arthritis Program, based on: Manninen D, Cox BG, Christian J. Preparing for ACHES (Arthritis Conditions Health Effects Survey) Final Report, vol 1. Seattle, WA: Battelle; 2006.

6) Charlotte Jacqmin, Hervé Servy, MSc, Physical Activity Assessment Using an Activity Tracker in Patients with Rheumatoid Arthritis and Axial Spondyloarthritis. JMIR Mhealth Uhealth. 2018 Jan.

7) Raja Bose, Abdelaslam, International Symposium on Observing Behavior of Humans Walking Using Distributed Phenomenon Detection and Tracking Mechanisms Year: 2008.

8) Qingzhon Qiu ; Da Guo ; Jianke Pan ; Zhenwei Ma ; Jun Liu ; Xuewei Cao 2013 IEEE International Conference on Bioinformatics and BiomedicineMutual information mining for component law and development of new recipes for rheumatoid arthritis Year: 2013.

9) Finckh A, Early inflammatory arthritis versus rheumatoid arthritis, Year 2008.

10) Goergina Kemp, Kay M. Crossley, Ben R, Metcaff. Reducing joint loading in medical knee osteoarthritis: Shoes and canes, Year 2008 25 April.

11) Michelle J Lespasio, Nicolas S Pluzzi. Knee Osteoarthritis: A Primer, 2017 September 13.

12) Maria Ntolopoulou, University of Birmingham, Biomechanics of assisted locomotion in elderly osteoarthritis patients, August 2016.

