OPTICAL GONIOMETER FOR KNEE JOINT ANGLE CONTINUOUS MONITORING

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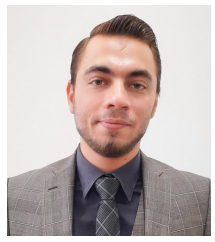


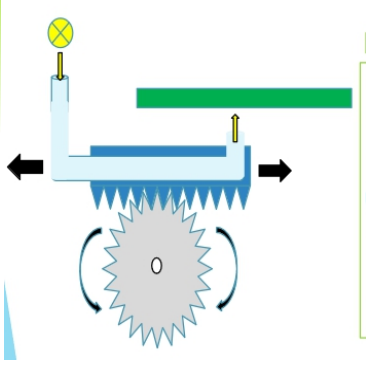
Introduction

- Knee joint is an important part of human body. People with poor knee condition generally have limited physical movement, rendering to mental stress and agony.
- Current technology to support the knee diagnosis and treatment procedures are limited to the use of manual goniometer, x-ray and magnetic resonance imaging (MRI).
- X-ray and MRI technologies are useful to have some insight on the knee problem, but they are not applicable for continuous monitoring.
- One of the key methods used by physiotherapist to assess knee health condition is by measuring knee joint angle during gait and identify the angular range for the knee movement of the patient in the frontal plane.

Related studies device's clinical applicability

No	Sensor	Gait Application (0-69°)	Sit to Stand Application (0-120°)	Supine application (0-155°)
1	Fiber optic curvature sensor	Not Applicable	Not Applicable	Not Applicable
2	Optical fiber bending sensor	Not Applicable	Not Applicable	Not Applicable
3	Fiber bragg grating	Applicable	Not Applicable	Not Applicable
4	Optical fiber goniometer	Applicable	Not Applicable	Not Applicable
5	Optical fiber goniometer	Applicable	Not Applicable	Not Applicable

Working Mechanism of Proposed Device



1. LED is connected to optic fiber cable.
2. Optic fiber cable is attached and fixed on the rack shaft, and the cable carries the light and transmits it to the other end of the cable facing the linear array photodiode sensor.
3. Gear rotates simultaneously with the knee angular movement.
4. Upon gear rotation, rack shaft moves linearly left or right depending on gear's angular direction.
5. Linear movement of the rack shaft varies the light beam pointing position on the sensor, allowing different pixels positions in the sensor to detect the light beam.
6. Different pixel position refers to different angle.
7. Hence, angular motion variation is translated to linear motion variation and a mathematical formulation is generated to translate the pixels position into angular reading.

Product Images

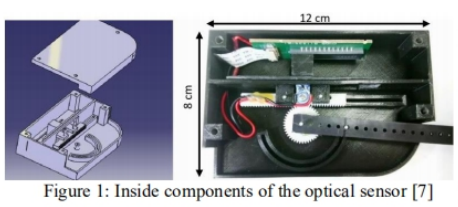
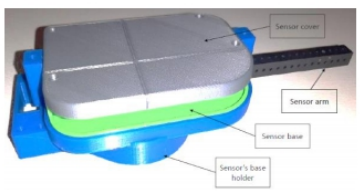
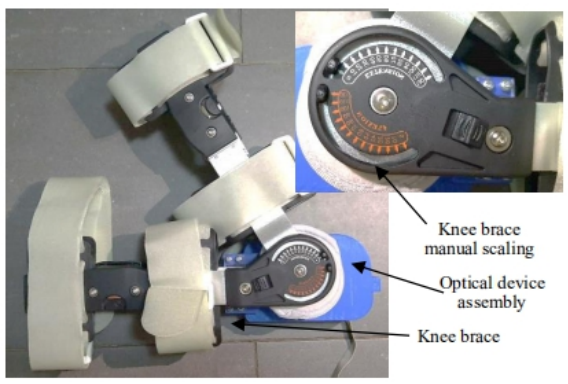
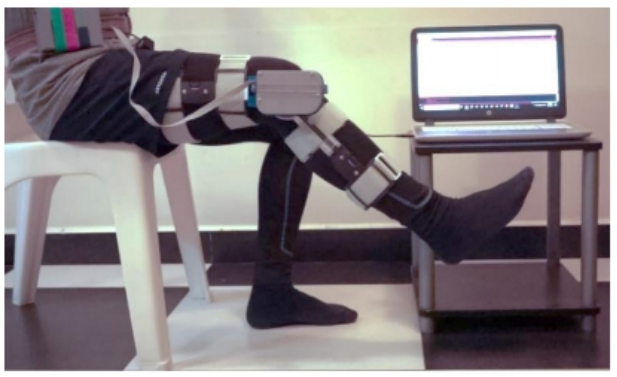


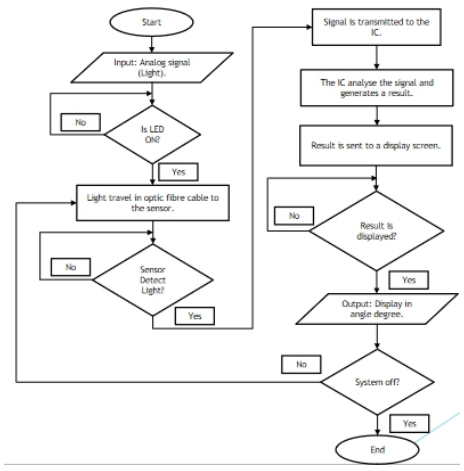
Figure 1: Inside components of the optical sensor [7]



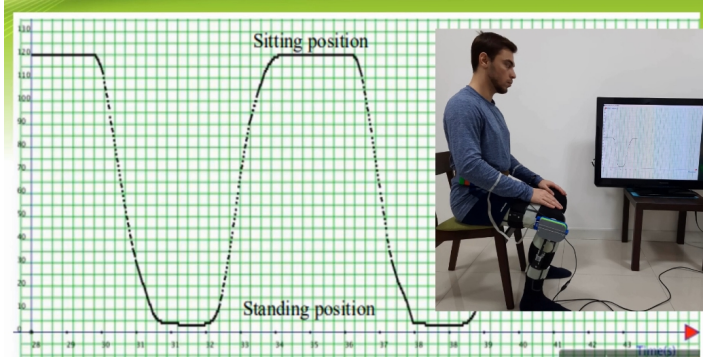




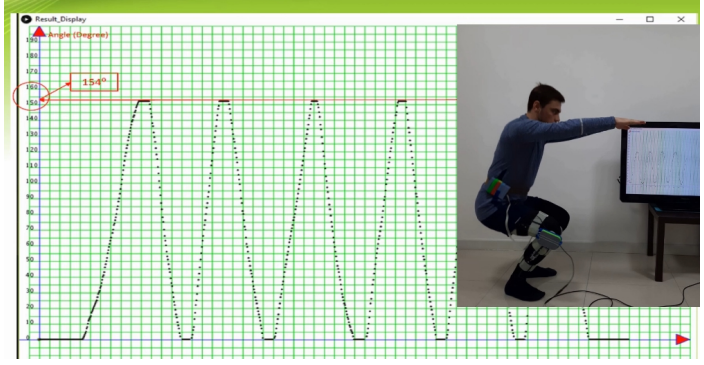
System Operation Flow Chart



Result Outcome Display



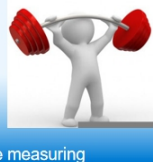
Result Outcome Display



Proposed Optical Goniometer Device Applicability

Test Condition	Min. Angle (Degree)	Max. Angle (Degree)	Proposed sensor
Gait	0 deg.	69 deg.	✓
Sit-to-Stand on Chair	0 deg.	120 deg.	✓
Ascending Stairs	0 deg.	99 deg.	✓
Descending Stairs	0 deg.	99 deg.	✓
Full flexion (supine)	0 deg.	140 deg.	✓
Full flexion (squatting)	0 deg.	157 deg.	✓

STRENGTH



1. New Concept, there is nothing like it in the market.
2. Improves Health and Lifestyle.
3. The only device using optics related technology that have a very wide measuring range, able to monitor the full knee range of motion.
4. Able to assess knee joint under dynamic and static conditions.
5. low cost
6. Easy to use and apply.
7. Does not cause any harm or side effect.
8. comfortable to the wearer and can help improve the condition of the knee joint.
9. Able to detect knee problems before they become injuries or permenent scar tissue.
10. Has very high accuracy ±0.04°, resolution 0.08°, 100% precision, and 200 result per second for repeatability.
11. Applicable for actual clinical environment.

Cost per Unit if 100 Units Manufactured per Month

Locally Manufactured

Electronic System -	MYR 700
Mechanical Components -	MYR 210
Programming -	Null
Labor Cost -	MYR 100
Total-	MYR 1010/unit

Not Inclusive Facilities cost (workplace, workshop, Etc..)

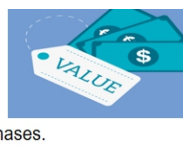
Components Manufactured in China, Assembled Locally

Electronic System -	MYR 403
Mechanical Components -	MYR 63
Programming -	Null
Shipping Cost-	MYR 2
Labor Cost -	MYR 100
Total-	MYR 568/unit

Not Inclusive Facilities cost such as workplace.

Safes atleast 43.8% Compared to manufactured locally

PRICING

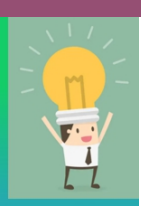


- In order to cover the overhead cost
- to be able to have cash liquidity in hand for future purchases.
- to have room for promotions and discounts.
- To be able to share margins with second or third parties that sells the product on our behalf.

It is suggested that 100% price mark up to be made on the manufacturing cost.

Thus, Selling Price is **MYR 2020.00** for locally manufactured and **MYR 1136.00** for manufactured in China and locally assembled.

OPPORTUNITIES



1. There is a great market demand for continuous monitoring device for knee joint.
2. Market scope is very big.
3. No competitor.
4. Can be made available in clinics, hospitals, rehabilitation centers, sport centers, or even personal.
5. Can be manufactured locally due to the availability of required components and technology.

Summary

- Current technologies such as x-ray, MRI and manual goniometer cannot fully support the continuous monitoring of the knee, rendering limited data can be made available for respective clinical personnel.
- Despite a number of alternative sensors introduced by researchers, these devices do not fully support the needs of knee application, especially due to the limited range of motion of those sensors.
- we demonstrate a wearable optical-based knee monitoring device, specially designed to allow direct attachment on a knee brace.
- The combination of the optical sensor and the knee brace made it possible to simultaneously strengthen the poor knee condition and to collect data related to the knee movement within a specific time period.
- The proposed optical sensor has a larger range of motion than other comparable optical-type devices, with a maximum detection angle of 160 deg. that is larger than required angle of maximum knee flexion of 157 deg.
- Based on current study, the proposed sensor has a range of motion between 0 deg. to 160 deg., 0.08 deg. resolution as well as support continuous monitoring of the knee.
- sensor is suitable for clinical application covering different activities of the knee such as gait, sit-to-stand, ascending and descending stairs and maximum flexion. More field test will be carry out with the help of local physiotherapist to further validate the sensor performance.

Publications

1. **Knee joint movement monitoring device based on optical fiber bending sensor** - *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*
2. **A Novel Implementation of Knee Joint Monitoring Device using Step Index Optical Fibre and Linear Array Photodiode Sensor** - *Journal of Physics: Conference Series 1529 (4), 042069*
3. **Mathematical Representation of Joint Angle Measurement using Step Index Optic Fibre and Linear Array Photodiode Sensor** - *Journal of Physics: Conference Series 1529 (4), 042089*
4. **Review of Human Joint Monitoring Devices: Conventional vs. Optical Fibre based Sensors** - *Journal of Physics: Conference Series 1529 (4), 042097*
5. **Knee monitoring device based on optical sensor embedded in mechanical compartment assembly** - *Optik - International Journal for Light and Electron Optics 223 (2020) 165546 (ELSEVIER)*
6. **Optical Sensor Assembly on Knee Brace for Continuous Knee Monitoring Application.** *"Optics & Laser Technology (ELSEVIER)"Status: Under Review*

Achievement/Award

- *Three Minutes Thesis Competition, 1st place, 2017. Faculty level.*
- *Three Minutes Thesis Competition, 1st place, 2019. Faculty level.*
- *Three Minutes Thesis Competition, 2nd Runner up, 2019. On all engineering faculties level.*
- *Three Minutes Thesis Competition, 1st Runner up, 2019. On Universiti Malaysia Pahang level.*
- *Three Minutes Thesis Competition, 2019, Participated on National Level.*

Collaboration

Collaboration with UITM, Puncak Alam Campus, Physiotherapy, Faculty of Health and Sciences

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