



Letter to the Editor

Smart sensors applications in orthopedics



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Dear Editor,

Smart sensors have the ability to communicate through digital network different parameters, and its applications are increasing in industries, medical, and its associated fields. Orthopedics doctors and surgeon want accurate and reliable results, so there is a requirement of use of the smart sensor to control and monitor all parameters for the better life of the patient. Intelligent orthopedics equipment like life supporting implants, tools, and devices use these sensors that are helpful to report development inside both equipment and body of the patient. Smart sensors are used to monitor blood pressure, anesthesia delivery machines, sleep apnea

machines, oxygen concentrators, infusion and insulin pumps, temperature, kidney dialysis machines, and fluid management system.¹

Recently, smart sensors are introduced in medical and in its associated field of orthopedics. The main focus of this technology is to increase healthcare efficiency.² It is used to enhance attention of monitoring, diagnosis, health screening, cancer screening, glucose monitoring, and automatic drug delivery. A smart sensor is a remarkable device that enables the accurate collection of data from the environment and records critical information. The essential components of this technology are excitation control, amplifier, transducer, analog filters, and compensation. Smart sensor is the type of sensor that can be made an essential component of a computer. It can sense human-related activities and other industrial automation and control system. Fig. 1 depicts the working principle of a smart sensor if used for orthopedics applications.

In industries, it is used in different applications such as robotic guidance, reading, counting, and sorting. These are helpful to measure and record physical, biological, and chemical signal. Physical properties such as pressure, temperature, vibration, weight, light intensity, sound level, a flow rate of liquids, and gases are sensed

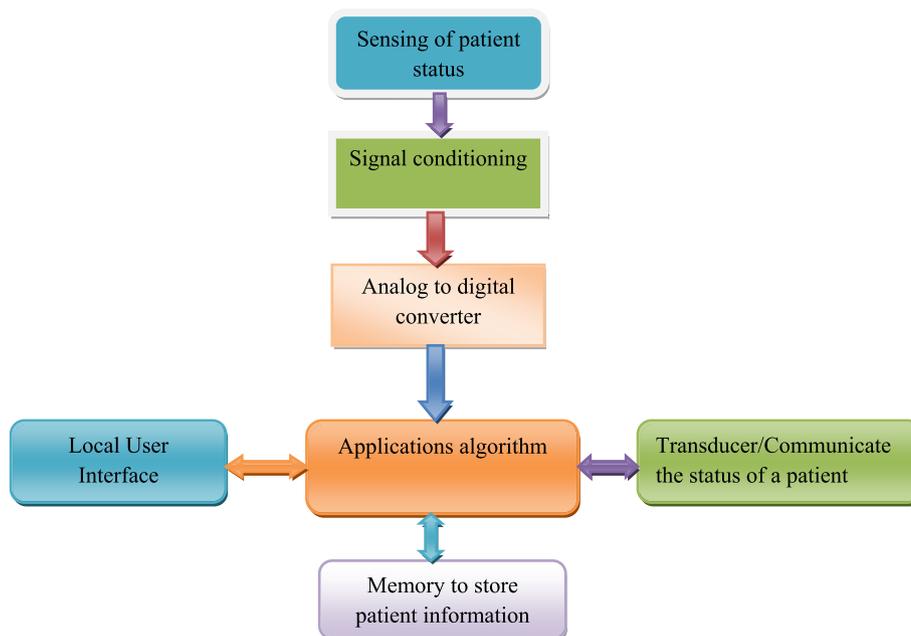


Fig. 1. Working principle of a smart sensor for orthopedics.

Table 1
Significant applications areas of smart sensors in orthopedics.

S.No	Applications	Description
1	Smart orthopedics implants	<ul style="list-style-type: none"> Smart sensors are providing extensive applications in medical sciences, especially implants in human body
2	Knee replacement	<ul style="list-style-type: none"> Smart orthopedics implants in the patient body for the replacement of missing bone or joint Knee replacement is the most common surgery in the orthopedics field precisely performed by smart sensors Easily measures the force exerted on the knee implants
3	Predict failure	<ul style="list-style-type: none"> These sensors easily track the forces/changes in the implanted part of the body It has excellent capability to sense mechanical failures, high risk of infection, and quality of operations and future symptoms
4	Personalized medicine	<ul style="list-style-type: none"> After surgery, it checks the status and improvement of the body part Smart implants can enable personalized medicine with improved outcomes of the individual patient
5	Monitor body parameter during surgery	<ul style="list-style-type: none"> It provides inside information of the body which is not possible by any other alternative way It can continuously monitor all parameters during orthopedics surgery Monitor and control the blood pressure, temperature, oxygen level, and all other essential parameters
6	Diagnostics device	<ul style="list-style-type: none"> Smart sensors carry diagnostics technology in the body During neck and low back pain, it provides valuable information to perform a successful operation
7	Bone growth measurement	<ul style="list-style-type: none"> It provides muscle activation in spine, activity, and role of posture Having the potential to measure and predict the growth of bone Check the status of old bone and replacement of the bone as per patient match Used to provide the measurement of fractured bone
8	Teaching and research	<ul style="list-style-type: none"> These sensors are also used as a research tool and helpful for teaching and training Creates innovation in teaching, practice, and research for the student by providing precise information of happenings inside the human body
9	Internet of Things (IoT)	<ul style="list-style-type: none"> Smart sensor is also an important component of the success of Internet of Things Easily adjust the output from the desired value and also provide the measurement
10	Industry 4.0	<ul style="list-style-type: none"> Helpful in Industry 4.0 to perform precise and efficient surgery Predict the cause of diseases and there better solution Examine patient-specific information to provide better health

easily.³ In today's industry, quality, safety, productivity, and reliability depend on the performance of the sensor use as they provide feedback to the production environment. Thus, it plays a critical role in measurement, monitoring, and controlling in the industrial system. Smart sensors are a critical component of the fourth industrial revolution commonly known as Industry 4.0, and they facilitate real-time data collection, connect factory, and provide a higher level of flexibility.⁴

This technology to obtain information about defective bone parts, health status, and surrounding biological tissue.⁵ Therefore, in orthopedics, sensors are used to create smart implants, as these sensors are helpful to provide valuable information to the surgeon. In the medical field, there is a growing problem for infection; these smart implants have great potential to sense infection.⁶ Wireless sensors are now replacing the wired ones, especially for implants. Smart sensing orthopedics implants are put inside the patient's body for the replacement of missing bones or joints such as elbow, hips, shoulder, knee, etc. These sensors communicate wirelessly to the control/monitoring equipment. Table 1 briefs important applications of smart sensors on orthopedics.

In future, this technology is capable of providing disruptive innovation in orthopedics especially for spine devices, trauma plates, and joint replacement. Smart orthopedics implants will easily measure load, motion, temperature, enzymes, and bacteria level. Sensors help provide adequate care to the patient, as they will help early detection of the problem and thus treatment can be initiated.

Smart sensors are quite new to the daily clinical practice. Another limitation is cost, power consumption, robustness, and size. They sometimes can create a high risk for human, with inefficient working and provide unreliable information.

Thus, smart sensors have the potential to be used for personalized medicine and clinical care. Smart orthopedics implants can be used in clinical applications for improving daily life practice. A smart wireless sensor can quickly put inside the orthopedics implants. The potential applications of these sensors are to monitor internal temperature and pressure and reduce the risk like tissue necrosis, implant failure and amputation—this help to improve the care of the patient in an efficient way. In the upcoming year, it will prove successful in the field of orthopedics for better care of the patient.

Conflicts of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cmrp.2019.10.002>.

References

- Connor CO, Kiourti A. Wireless sensors for smart orthopedic implants. *J Bio Tribol Corros*. 2017. <https://doi.org/10.1007/s40735-017-0078-z>.
- Lu S. *Smart Sensors in Healthcare*. Industrial Engineering & Management; 2014. <https://doi.org/10.4172/2169-0316.S1.001>.
- Wilson CB. Sensors 2010. *BMJ (Clinical research ed.)*. 1999;319(7220):1288.
- Haleem A, Javaid M, Vaishya R. Industry 4.0 and its applications in orthopaedics. *J Clin Orthop Trauma*. 2019;10(3):615–616.
- Ledet EH, Liddle B, Kradinova K, Harper S. Smart implants in orthopaedic surgery, improving patient outcomes: a review. *Innov Entrep Health*. 2018;5:41–51.
- Karipott SS, Veetil PM, Nelson BD, Guldberg RE, Ong KG. An embedded wireless temperature sensor for orthopedic implants. *IEEE Sens J*. 2017. <https://doi.org/10.1109/JSEN.2017.2780226>.

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