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Wireless Sensors in General Anesthesia- An Update

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Abstract
Wireless sensor networks (WSNs) give wireless connectivity with computing power to monitor patients, during anesthesia in surgery. A Boyle's Continuous anesthesia machine administers anesthetic gases in combination with oxygen and real time monitoring of oxygen saturation in blood, EEG, Body temperature,Blood pressure,heart rate, evolved carbon dioxide (Depth of anesthesia DoA) help anesthesiologists plan safe anesthesia. Medical sensors are attached to the patient's body to collect the patient's physiological data. Wireless transmission of the collected data to a medical staff's portable device. This update gives insight into recent developments in Wireless Networking Sensors in Critical Surgery including Anesthesia, WSN Architecture, Challenges, Network Security (Encryption) developments in Smart Medical Systems with general domain of remote patient monitoring, focused on anesthesiology care in particular how WSN and IOT will help Anesthesia in automated administration and monitoring

Keywords: Wireless Sensor Network, Anaesthesia, Encryption, Monitoring, Physiology

Introduction

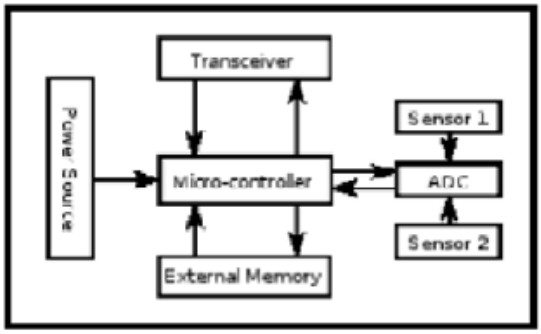
Recently, in health care, there has been growth in wireless service networks, dueto technological developments in medicine, surgery and low-power networked systems. Such networks have a cutting-edge component in the healthcare; they enhance quality of patient care without sacrificing patient comfort.

With limited memory, lower processing power, low battery and low bandwidth such sensors remain attached to the patient's body from where collect patient's physiological data and wireless transmitting to a portable device. Use of a health monitoring system is a promising research area in Wireless Sensor Networks and uses sensors to sense physiological activities in patients and the acquired information is used to alert caretakers of patients. Advancements in enduring healthcare monitoring could stop or rapidly reduce the incidence of illnesses and accidents. Simple sensors have limitations and locations; wired communication among sensor modules does not allow a patient to move freely from one place to another place [1, 2].

This Literature review is focused on Use of WSN in Anesthesia in surgery and organized as Sensor Classification, Research in semiconductor technology, wireless Networking Sensors in Anesthesia in Surgery and Futuristic scope and outlook.

Definition of WSN: Self configured, infrastructure less wireless network for monitoring parameters including temperature, vibration pressure and if employed in medicine to monitor human physiology parameters real- time dynamically.

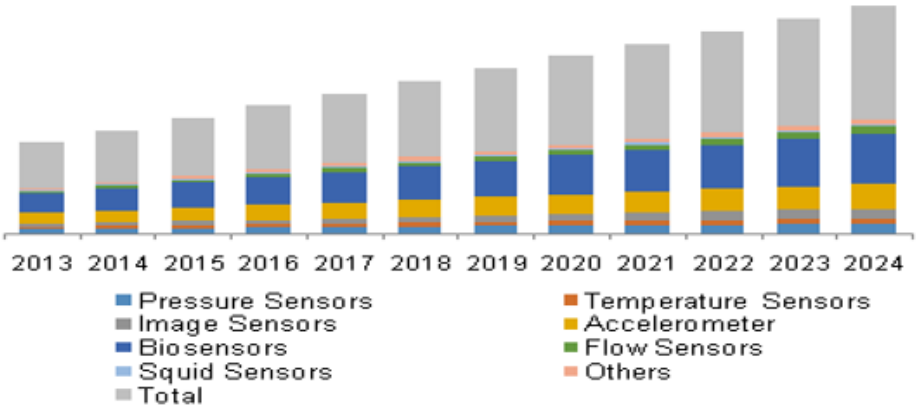
General Working of WSN



Controller ; Processes data, controls functionality of components in the sensor node.
Transceiver; Employs radio frequency (RF), optical communication (laser) and infrared.
External memory On-chip memory of a microcontroller and Flash memory off-chip RAM. Flash memories are used due to their cost and storage capacity.
Power source
A wireless sensor node is a popular solution when it is difficult or impossible to run a mains supply to the sensor node

Fig 2
Sensors
- Wireless sensor nodes capture data from their environment.
- Hardware devices that produce a measurable response to a change in a temperature or pressure.

Medical Sensors Market Analysis, By Product (Pressure Sensors, Temperature Sensors, Image Sensors, Accelerometers, Biosensors, Flow Sensors, SQUID Sensors), By Application Area (Surgical, Diagnostic, Therapeutic, Monitoring), By End-use (Hospitals, Physician Offices, Nursing Homes, Home Healthcare) And Segment Forecasts To 2024.Report ID: 978-1-68038-926-5, 2013-2015 Industry: Healthcare



Classification of Sensors

Analog and Digital

Physical properties of the body can be measured by using different sensors like body temperature, heart rate, pulse rate, respiratory, and heart rate. Common types of sensors include Ultra-Sonic Pressure Based, Infra-Red Radiation based, Thermo-couple and /or Temperature based, Gyroscopes, Light-Based sensors, Color based touch-based, half effect-based Metal Detector based, and Proximity Sensors.

Infra-Red Sensor Dynamically varying signal generated in an IR sensor gives values generated are very small, it is measured in micro volt or milli-volt, signal of a analog type is than converted to digital value by using a Analog Digital Converter device.

Temperature Sensor Thermocouples, temperature resistance resistors, Thermistors, and Temperature Sensor ICs.

Proximity Sensor Physical contact with an object goes unnoticed. Distance measured is considered the target. An infrared light source or some electromagnetic radiation is employed. Proximity sensors include Inductive, Capacitive, and Ultrasonic types.

Light-Sensor A Photo-detector emits digital signal then calculate speed by a disc attached to a rotating shaft. A sensor passes through each slot in the shaft. An output pulse as logic 1 or logic displayed on a LCD.

Digital type of Accelerometer An accelerometer may produce variable type of frequency with a square wave with a Width modulation. When an output produced in a PWM signal pulse width is in direct proportion for acceleration. Other sensors like digital temperature sensors.

Medical Sensors

Sensors giving patients and their health professional are insight into physiology, physical health, mental status that is relevant for the detection, diagnosis, treatment, and management of diseased conditions.

With use of medical devices in hospitals, clinics, and homes it would be practical to monitor a patient's status with thermometers, blood pressure monitors, Glucometer, electrocardiograms (ECG), photo seismographs (PPGs), electroencephalograms (EEG's), and modern imaging sensors.

Cardiac international pacemakers and insulin are enabled to measure the physiological conditions continually. It estimates characteristics indicative of human health. Sensors that directly evaluate the health status are also used in proximity sensing technology.

Historical Perspective

Long history of using sensors in Medicine and Public health. Sensors Embodied in medical instruments used in hospitals, clinics, and homes. This sensor provides patients, their healthcare provider's data on physiological health states on real- time basis.

Critical to detection, diagnosis, treatment, and management of disease and during surgeries. Modern medicine without sensors LIKE thermometers, blood pressure monitors, glucose monitors, EKG, PPG, EEG, and imaging sensors difficult to even perceive.

Semiconductor technology

In1990s the semiconductor industry began to standardize processing methods for semiconductor devices where the hardware required large-scale implementation of WSN applications. Network designers did not use bulky discrete circuits or multi-chip solutions. A wireless system-on-chip device that combines a general-purpose micro controller and RF transceiver on the same chip contains powerful

peripherals like amplifiers, ADCs, DACs, and persistent disk that can handle application and network protocol stack[3,4]

Wireless Networking Sensors in Anesthesia in Surgery General or Whole Body Anesthesia

A state of controlled, temporary loss of sensation or awareness induced for a medical purpose (Surgery). It includes Analgesia, Amnesia, Unconsciousness, Muscle Relaxation.

Stages of General Anesthesia

Stage 1: Induction, Earliest stage (Propofol, Thiopzentone)

Stage 2: Stability in Physiology, Vitals, Artificial Respiration

Stage 3: Surgical anesthesia (Gas- N20+HALOTHANE)

Stage 4: Surgery Performed- Completed.

Revival from Anesthesia - POST ANESTHESIA CARE UNIT

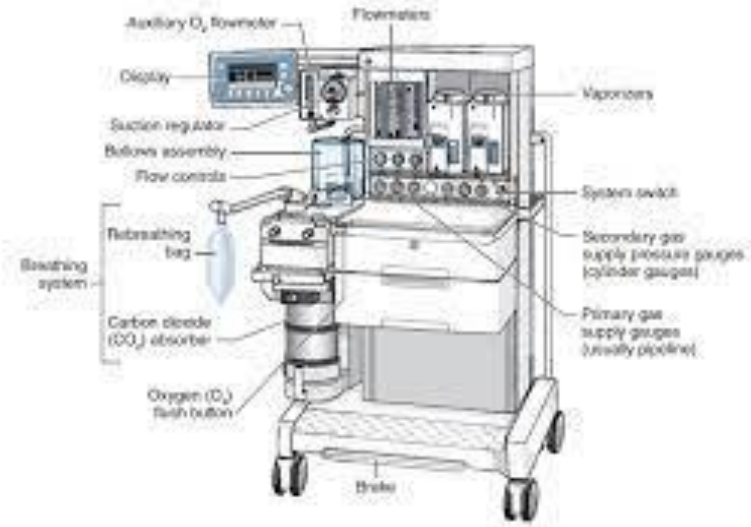
The modern integrated anesthesia workstations designed to work as a complete anesthesia and respiratory gas delivery and monitoring system that combines advanced ventilation features, gas delivery and agent vaporizing with patient monitoring and information management to form an integrated anesthesia care-station.

Modern Anesthesia monitors are open-source communication interface type that permits hard wired connection of the monitor to recording system. They have Integration of monitor's data generated by other medical devices. If monitors are connected to a server-based patient information system it can transmit data to a mobile device.

General anesthesia means a drug-induced, reversible condition in which the patient remains unconscious and is unresponsive to any painful surgical stimuli called sedation status that is achieved by intravenous administration of a cocktail of medications including a muscle relaxant, hypnotic, and analgesic agent. A balance of gas and infra-venous drugs is crucial to ensure quick onset and an accurate Depth of Anesthesia during induction phase, to ensure pleasant and short recovery time after surgery[4,5,6,7]

General Anesthesia Machine

(Source: https://www.brainkart.com/article/Resuscitation-Breathing-Systems).



Landmark Developments in Use Wireless Sensor Networking in Anesthesia Monitoring

Health monitoring systems are important and research on health monitoring were developed for applications like military, home-care unit, hospital, sports training and activity emergency monitoring system. A wearable and real-time monitoring system for critical vital signs in patient's age over 60 years may help doctor or people in family monitor the emergency alarm from patient. It consists of blood pressure, heart rate, oxygen saturation, body temperature and respiratory rate. That vital sign can measure by using device namely; pulse oximeter. The pulse oximetry data are important for doctor to monitor patient's health condition. Implementation and design of wireless sensor network for real-time health monitoring system using ZigBee wireless standard, and demonstration of pulse oximetry data (heart rate and SpO2) monitoring on the patients designed for reducing the cost, size and comfortable in daily life usage. Further planning may include 3-axis accelerometer and gyro-sensors to compute algorithms for classification the human movements and human activities[9]

Functions of an Anesthesia Machine

1. Assess patient's health and begin administering the next dose of anesthetic agent,
2. Check the presence of gas in operating rooms. Alerts personnel in leakage, Lessens risks associated with anesthesia.
3. Indicate anesthetization upcoming dosage

If a large anesthetic dosage given at once it puts the patient's health at danger though an anesthetist is available for operations to provide anesthesia at intervals. An automated syringe pump based on the Raspberry Pi has been successfully constructed and the test data examined in order to evaluate the system's functionality in studies earlier. Reduced oxygenation during post anesthesia period results in impairment of pulmonary function which occurs even in healthy individuals. A 50% reduction in functional residual as may result in pulmonary atelectasis i.e. dysfunction in a lung lobe. Majority of patients in the post - anesthesia care unit have atelectasis as their primary cause of postoperative hypoxaemia.Correct use of anesthesia and analgesic techniques influence pulmonary outcomes in the Post Anesthesia Care Unit (PACU) . In order to avoid such a scenarios automated use of WSN - Raspberry Pi has been useful in surgery for a successful procedure since anesthesia is essential for painless surgery[10]

In a recent study, design and development of sensing system for volatile anesthetic gas based on WSN included smart sensor chip fabricated by dip coating conducting polymer for sensing sevoflurane, an inhalation anesthetic agent. It included a sensing module, data acquisition module and wireless microprocessor module and results gave a rapid sensor response with potential application in indoor environments in hospitals[11]

Cardiovascular diseases and cardiovascular monitoring are vital in anesthesia in surgery as they are a major cause of mortality globally and to avoid accidental deaths heart rate, pulse rate and electrocardiogram (ECG) using a 3 - tier architecture prototype wireless sensor network (WSN) which was developed to continuously monitor body parameters to measure heart rate, body oxygen level and temperature attached to Arduino Nano board and recorded and using Thing Speak, an internet of things (IOT) application with an accuracy of 95% and response time of 10 seconds was developed in India[12]

Any surgical procedure requires anaesthesia and to prevent unfavorable occurrences, an automated anesthetic controller using a Raspberry Pi WSN device where the anesthetist by a switch panel takes control of the setup by directing a motor driver to start anesthetic infusion, while considering heartbeat,

temperature, oxygen saturation level, and body moisture state was developed successfully. The automated syringe pump based on the Raspberry Pi could operate in a volume range of 0.10 - 30.00 ml, flow rate resolution 0.10 ml - 1ml with error less than 5 percent[13]

In the hospitals, during major operation the patient should be anesthetized for pain free operation. Single dose anesthesia administration for prolonged operations may lead to complications. In case of insufficient anesthesia dose, the patient may feel pain and discomfort during operation. Therefore, there is need for an administration of exact dosage to the patient, at the particular time interval. An automatic anesthesia administering machine is proposed to overcome the crucial issues. The anesthesia should be given to patient in the correct dose at regular interval based on patient conscious state. The brainwave sensor is placed on the frontal side on the scalp. Brains action will be monitored constantly. When the patient gets deviated from the sleep state the correct level of anesthesia is injected by using servo motor by analyzing the brain activity. The microcontroller and brainwave sensor are interlinked using bluetooth module where the data are processed and sent to raspberry pi which gives commands to servo motor to pump the required amount of anesthesia to the patient. In addition to this heart rate and temperature of the individual are recorded[13]

Futuristic scope and outlook.

1. Development of a module, that may be connected to the anaesthetic ventilator for future use. It should assess the patient's blood sugar level(insulin) and determine whether or not the next dose should be administered.
2. WSN for interacting with EEG parameters for major procedures.
3. Even if a anesthesiologist is not present physically, amount of anaesthesia that is needed is exactly predicted and given thus preventing variations in anaesthetic levels and achieving the correct depth of anesthesia
4. To ultimately make Anesthesia machines verbally interactive with notifications indicated automatically using software sent by a SMS, email or Bluetooth messenger.
5. EEG data Recording and consequent notifications sent to anesthetist as a parameter of brain activity .

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