

Continuous and Predictive Remote Wellness Monitoring with IOT and AI

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Abstract— Pandemic has challenged global economy disrupting the current way of doing business. Business continuity is on steroids is the new normal and demands being Proactive on wellness. Identity + Wellness is essential at every access point and every closed engagement location like front office, back office, class room, staff rooms, recreation rooms, Library. To ensure Wellness, comprehensive health screening is the new normal along with information security and compliance. The new normal will continue to impact with various lockdowns impacting the manufacturing, banking and education sectors that are back bones of a nation.

The existing methodologies lack continuous monitoring and are designed to monitor at the entry or access with a temperature screening, face mask detection providing monitoring only at the instance. Alternatively Contact tracing with too many data points irrelevant to impact when found reactively post any wellness impact in case any individual is impacted. Both methods provide very low hit ratio of tracing others with possible anomalies for early isolated assessment or identifying potential impacted crowd. Vaccination though being a preventive measure, there is no one solution to prominently eliminating any viral impacts to human to resume business as usual

In the US 5,800 small U.S.-based businesses, published in July 2020, revealed that 41.3% of the businesses were “temporarily closed because of COVID-19,” while 1.8% had closed their doors for good

The unique IOT and AI solution brings in advantage of continuous monitoring of employees or students with body skin temperature and integrated contact tracing with predictive analytics on the big data creating informed decisions enabling the authorized human agents to isolate for early diagnosis upon any detection of anomalies

Keywords: Wellness monitoring, COVID monitoring, business continuity in pandemic, IOT, Machine learning, continuous body skin temperature monitoring, Industry agnostic

INTRODUCTION

When there is a disaster, there was always a plan for business continuity. But when the world faced pandemic and in the current economies the impact of livelihood wellness was well felt impacting GDP. In the past 2 years of pandemic and go forward wellness is an integral part of business continuity and compliance for access, presence to monitor for any anomalies that would redirect to authorities for proper assessment and isolation preventing spread assuring business

The designed IOT system will be worn by students and workforce in the arms as an arm band that would continuously monitor body skin temperature, alert on any just in time temperature anomalies using predictive AI. Upon assessment if the individual is found impacted, a predictive analyser detects human around them on premise along with the temperature thus reducing time lag and reduce time of spread by trace of contact

PREVAILING METHODS AND CHALLENGES IN ANOMALY DETECTION

Thermal Guns

In the entry to premise, just in time check and very close proximity in case of any body temperature anomalies, no opportunity to detect post entry to the premise, demands high human efforts and operational expense. No specific learning methodologies to predict on the device. Best case scenario is utilizing Weak AI algorithm that correlates big data into usable information by detecting patterns and making predictions

Monitoring temperature on Thermal Cameras

Performs only just in time check, expensive, extensive installation and maintenance, demands higher level of AI learning curve. Designed with computer vision with artificial intelligence that trains computers to interpret and understand the visual world. Machines can accurately identify and locate objects then react to what they “see” using digital images from cameras, videos, and deep learning models



Fig. 1. Monitoring by continuous detection

Contact tracing

Limited to social distance between individuals alerts and does not detect any just in time anomalies leading to false positives. It is always reactive if someone is tested for anomalies and to back track to find anyone in close proximity and needs to be tested for anomalies as well. The AI learning model that can be applied is aligned to K Means clustering AI Algorithm and with analytic and interactive data types. Technologies used are Bluetooth or Ultrasonic / Bluetooth (emerging) for contact tracing. It is mostly mobile based and challenges the privacy aspects. The above methodologies are monolithic in nature and demands very expensive post-mortem to identify in trace post identification of impacted candidate

The prevailing technology gap is missing to have an edge intelligent platform that will be scalable to plug and play various types of sensors automatically creating a digital twin enabling monitoring of anomalies assuring business continuity at enterprise scale

SECURED & PREDICTIVE ANOMALY MONITORING USING AI AND IOT

Muralidharan N, designed a technology platform design that continuously monitors anomalies for every specified interval through a device designed to measure and monitors body skin temperature along with subjects at a prescribed contact traceable distance compliant to Too close for too long (TC4TL) on premise that enabled the impact of neighbours. Monitoring is done specific to premise for event handling and does no track the location of an individual except notification of presence or absence from the premise with or without anomalies and TC4TL

A. Detection of anomalies bigdata K Means Clustering

The smart remote anomaly monitoring is catered by Industrial IOT with edge intelligence, K-Means Clustering AI Algorithm with analytic and interactive data types as a digital twin were utilized to arrive at the architecture for remote continuous monitoring with edge intelligence

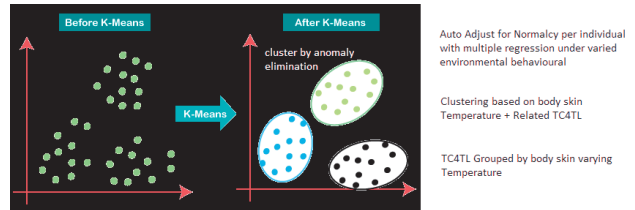
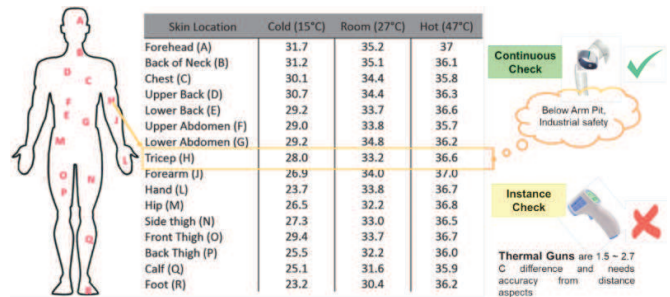


Fig. 2. K Means clustering model

B. Body skin temperature for continuous monitoring

Body skin temperature is most accurate without any calibration to be utilized for temperature monitoring on the human body. The measurement of skin temperature is highly dependent on the **location** of measurement and also ambient temperature, as explained in designing thermoelectric generators for self-powered wearable electronics [DOI: 10.1039/C6EE00456C]. Body skin temperature accuracy along with permissible industrial safety allowed us

In combination with Contact tracing TC4TL, it eliminates opportunity to wait till someone shows up for diagnosis and track TC4TL candidates



THE EDGE INTELLIGENT HARDWARE (IOT BASED ARM BAND)

Fig. 3. Body skin on triceps with industrial safety

On the hardware edge side of the platform, the edge intelligence defines dynamic behaviour based on use cases. Provided with the following options:

C. *The Arm band:*

The wearable worn by staffs and students in the arm when they are on premise. Safely worn below the clothing close to armpit compliant to industrial safety preventing wearing of watch in arms, neck, shoulders

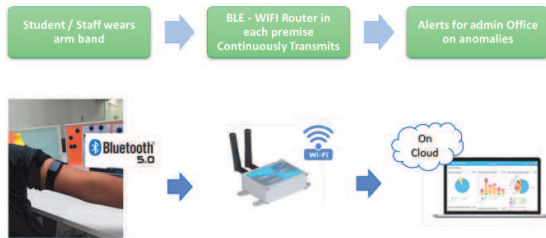


Fig. 4. Arm band and BLE modem with streaming data

D. *Wireless Technology used to build thermal armband*



Arm Band wearable ASTM E1112 and ISO 80601 designed for thermometers

Fig. 5. Arm band and bio strap with 99.5% pure Copper for better temperature conduction

BLE short range technology is used to monitor temperature and BLE operates at a maximum data rate bandwidth of 1 MBPS on the band worn by the student and staff

E. *Salient operations specifications*

1. **Skin Temperature** is the methodology for any quick temperature detection. Typically, 36.1 ~ 36.7C **body Temperature** in Arm pit area = 33.15 ~ 33.40 C **on Body skin**
2. Arm band 10 ~ 15 CMs away from armpit, position that provides best continuous monitoring
3. Sensor designed towards ASTM E1112 and ISO 80601 requirements for thermometers

4. **Sensor Accuracy** on body skin: +/-0.1°F between 95°F to 100.4° & +/-0.2°F between 100.4°F to 113°F
5. Ability to profile individual skin temperature profile and improve post data collections

Crowd Mode: Option to drive the entirety of data from the device to the AI and analytics cloud. This crowd mode helps to monitor with audit trails between normality and abnormal conditions with surplus data points with short range contact tracing within 6 feet. This mode consumes high battery power and may need replacement of batteries once in 2 months

Individual Mode: Alternatively, the edge intelligence can operate in sleeping technology mode, where until an anomaly is detected, the device will be in low power, energy saving mode along contact tracing limited to the premise at 30 Feet radius. Once an anomaly is encountered, just in time communication is established from the edge. This helps in long battery life, demand of low storage. This mode consumes verylow battery power and may need replacement of batteries once in 9 to 12 months

F. *Armband location tracking of individuals*

Armband does not have location tracking capability at all. Armband is hooked on to the BLE-WIFI Router provided in each class room or in the bus detects and collects the armband temperature anomalies for sending alerts. This device does not get connected to mobile for security and is transmitted through secured BLE-WIFI modem transmitted to controlled admin data premise. Compliance to HIPPA can be enabled with out display of name, age as demography in the dashboard

G. *Safety of battery in the armband*

Armband has a non-rechargeable CR Lithium battery replaceable in 2 to 9 months based on enabling of features. Hence the opportunity to charging hazards is eliminated

H. *Arm band anomaly detection*

Armband continuously monitors and detects only body skin temperature anomalies and set Exceptions on being in the designated premise like classrooms, staff rooms, library, bus etc... Does not infer any fever and always routes to the authorities to examine with proper experts for isolation exceptions

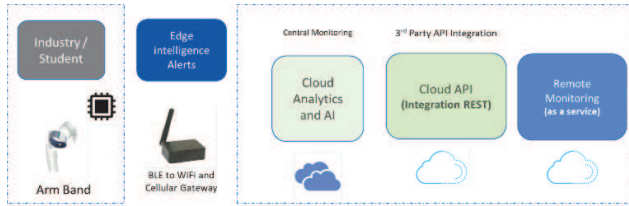
BIGDATA AI PLATFORM FOR SMART WELLNESS TRACKING

The platform designed to receive the big data is processed through high-speed messaging server, processed by streaming server by applying K-Means Clustering AI Algorithm with analytics and interactive data types as a digital twin alerting with better accuracy helping operations to resolve leading early isolation and predictive crowd TC4TL contact traced candidates for anomaly assessment. Set up the

organization, school, classrooms and operating management to set up continuous monitoring

A. Alert abnormal body Temperature:

Monitor body skin temperature of student and staff once in 3 minutes and alert the school admin



once temperature crosses prescribed (Configurable) value. Based in varied environmental condition, when the temperature returns to permissible limits, the alerts get auto closed for operational efficiency

B. Audit trails:

All Machine-to-Machine exceptions are audit trailed for future references and compliances

C. Alert presence in the Premise:

Monitor staff and student once in the classroom and alert on unavailability as per prescribed (configurable) time

D. Alert arm band removal:

During business-as-usual hours, any band being removed or band unavailable due to technical snag are alerted

E. Leaderboard dashboard:

Temperature anomaly detected, Band not worn, Gateway unreachable, Auto resolved

F. Workforce management

For anomaly management with human intervention for exception management



Fig. 6. Intuitive FMS with auto alert creation

THE SOLUTION OF WELLNESS MONITORING PLATFORM

Fig. 8. Architecture, High speed messaging, streaming and Timeseries big data

PLATFORM STACK ASSURING SCALABILITY WITH NEXT GENERATION SENSORS

Multiple stages of data processing from Edge to Big data services deployable in any cloud environment. Scalability is the key as the upgrading sensor world. Support of protocols for addressing wellness sensors are provided and onboarding the sensors will be though simple schema driven activities making this platform as a marketplace for sensors

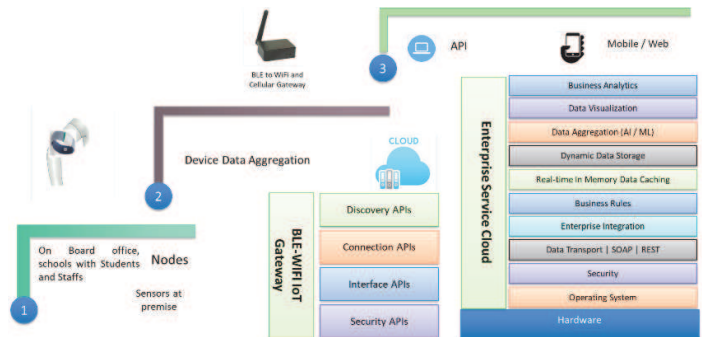


Fig. 9. Data Layer and microservice deployment model

TYPICAL COGNITIVE DICTIONARY FOR AUTO LEARNING

The platform allows the administrative users to create the industry entity, branches and demography. Platform also allows bulk processing of people to be monitored for quick set up. There is also a rule-based decision support for exception anomaly alert management for transforming unstructured data into a standard operating exception along with audit trail management. Typical Exception anomaly alerts, boundary condition along with auto close with resolution based on past data-based prediction

Anomalies	Detection Algorithm	No Alerts	SLA / Breach	Alert Setting Amber	Alert Setting Red	Auto Close
Band Not Worn	Temperature of Band during business hours	> 30.50 C	60 minutes on Amber to Escalate	0.00 C ~ 30.50 C	NA	> 30.50 C
Temperature Detected	Temperature of Band during business hours	31.01 C ~ 34.69 C	60 minutes on Amber to Escalate	> 34.00 C	NA	<= 33.99 C
High Temperature Detected	Temperature of Band during business hours	31.01 C ~ 34.69 C	90 minutes on Red to Escalate	NA	> 35.00 C	<= 33.99 C
Unreachable (Band Challenged)	Interrupted Signals to Application by Time	NA	30 minutes on Red to Escalate	NA	> 20 mins	Once Reachable
Gateway Unreachable (Modem Challenged)	Interrupted Signals to Application by Time	NA	30 minutes on Red to Escalate	NA	> 20 mins	Once Reachable

Fig. 10. Truth table for base dictionary to begin monitoring for auto regulation

ASSUMPTIONS HANDLING BEHAVIOURAL ANAMOLIES

These are assumptions and mitigation as the intention of the platform to identify predictive anomalies-based body skin temperature. Technology platform is purposed for assuring wellness eco system with operational efficiency and does not involve healthcare and diagnostics

1. **Detection of Asymptomatic** is handled with additional monitoring of neighbours in trace who are non-asymptomatic and will emit higher body skin temperature along with TC4TL. It would take certain time up to 2 days in such cases to detect through anomalies
2. **Body skin temperature is not to identify Covid** or any other disease and is intended for early alert to be notified in a crowd that helps the decision makers to isolate the subject to involve healthcare experts at an early stage preventing spread due to TC4TL
3. Few individuals may have different normal body skin temperature and is automated with AI to set normal temperature post few iterations of monitoring based on environment
4. Configuration systems will allow the admin to intervene and set the boundary conditions

CONCLUSION

Assess and validate wellness of every visitor, student & employee at every access point and On-premise is a new normal beyond pandemic. Wellness on-premise with identity and opportunity to isolate a suspect detected with any anomalies with a predictive reference while protecting private information and compliance is the new digital identity that is monitored continuously

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