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IOT Based Monitoring Of CT Scanner Performance And Equipment Safety

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Abstract—
CT scanners are an essential diagnostic imaging modality that uses x-rays to acquire cross-sectional images. Consistent performance from the system and routine quality control will guarantee the safety and reliability of operation of this equipment. Any problems will be able to be spotted in advance with the help of routine maintenance and checking of radiation-related parameters. Conventional methods of monitoring will include routine testing, logging of data and reporting. However, there could be problems that arise between the routine checks of the equipment. This paper proposes a framework for monitoring CT scanners based on IoT technology. In the process, non-invasive data such as the temperature and humidity of the room where the equipment is installed, equipment status, run time, error codes, cooling system, and selected parameters of quality control will be collected. The information will be uploaded to a server or cloud dashboard through a secure gateway which will allow monitoring of the thresholds, trends and alerting about the unusual parameters. The framework will also allow registering maintenance problems, escalation of the alerts and reviews by Radiographers, Service Engineers, and Medical Physicists. A descriptive design-based methodology will be applied for identifying which parameters will be measured, sensor and data configuration, alert systems creation, security features and evaluation of this framework. As this paper does not include any clinical or equipment testing, the results chapter of this paper will discuss outputs that would be expected from this framework and evaluation of the framework. This framework needs to be used as an additional tool for manufacturer guidance, statutory safety guidelines, acceptance testing or quality control program managed by certified specialists. The use of this IoT framework might improve equipment availability, early detection of problems, better documentation and safer CT services.

Keywords— Internet of Things , CT Scanner, Real-Time Monitoring, Equipment Monitoring, Predictive Maintenance, Sensor Technology, Fault Detection.

1.INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Computed Tomography is one of the most important methods in medical imaging, and this method is commonly used in many medical disciplines such as emergency medicine, trauma, oncology, neurology, and thoracic imaging. In CT scanning there are different components in the machine which include the tube, detectors, gantry, patient table, data acquisition, reconstruction software and computerised systems. During the scanning procedure, X-ray tube and detectors will rotate around the patient while collecting data from the patient. This data will then be used to reconstruct an image using computerised systems which will help clinicians assess patients' internal structure.

Since computed tomography involves the use of ionising radiation as well as complicated electro-mechanical components, it is important that the quality of images produced and safety of the system is



maintained. Changes in different components of CT such as the detectors, tube, calibration, patient table, cooling and reconstruction might have an effect on image quality, workflow and safety. Environmental conditions might also have an influence on the performance of CT system such as room temperature and humidity. It is only possible to provide quality CT service through having a quality management system.

1.2 PROBLEM STATEMENT

Most departments also have a maintenance schedule, regular phantom scans, manual fault checking and recording. Although this is a good practice, this can create problems in terms of time in between each maintenance. This means that there will be accumulated faults that only get reported when there is an error message or when the quality of imaging has been changed, delayed scans or non-functioning scanning device. Data can also be dispersed into other systems such as equipment logs, maintenance logs, QC sheets and room conditions. Unless all of these data are considered, it is quite hard to see trends and recurrent faults.

The major problem that needs to be addressed in this paper is the lack of a centralised approach to regularly check some pieces of information regarding the equipment performance and safety. The use of IoT-based monitoring system would allow integration of all of these data and give early warning signals. The development of this kind of system requires thorough work because the CT scanners are considered regulated medical devices and connection to control network without prior consent may affect cybersecurity and patient safety.

1.3 AIM AND OBJECTIVES

Develop an IoT architecture that will help in monitoring continuously the performance of CT scanners as well as equipment safety.

Specify the kinds of data to be monitored.

Develop an IoT architecture that will enable capturing, transferring, storing, and presenting data.

Specify rules to be applied in alerting the users regarding any irregularities in the data, repeat occurrences of error codes and maintenance needs.

Explain the role of the monitoring data in quality assurance activities.

Highlight the challenges associated with cybersecurity, privacy, workflow, and regulation.

Specify metrics to assess the effectiveness of the architecture.

1.4 SIGNIFICANCE AND SCOPE

The new proposed system might prove to be useful for Radiographers, Medical Physicists, Biomedical Engineers, Service Engineers and Radiology Managers. Radiographers may be informed about the condition of the machine and its notifications recorded. Medical Physicists may be provided with additional information that will assist in quality control checks. Service engineers may have information regarding the faults before visiting the site. The managers may be able to use the equipment availability information and downtime to schedule services.

The monitoring and decision making system will only consist of these two activities. There won't be any modifications done to the scanning parameters or direct control of the X-ray machine. Also, there won't be any requirement of patient imaging and identifiable patient data for the monitoring system. In case there are plans to integrate the system in the future, with the clinical information system, then another review will be required.

2. LITERATURE REVIEW

2.1 INTERNET OF THINGS IN HEALTHCARE

Internet of Things is a term used to describe a network of physical objects that have sensors, software and communication capacity enabling them to collect and share data. Within the health sector, such devices will assist in monitoring, managing assets, observation of environment, and communication between clinical systems. Islam et al. (2015) [3] have reviewed IoT within the health care setting and described the influence of network architecture, data handling, security and privacy in this sector. The paper reveals that although connectivity will create many opportunities for this sector, sensitive health care settings require special information and device protection. (Ner et al., 2026 [6]; Singh et al., 2026 [8]; Goyal et al., 2026 [13]; Gautam et al., 2026 [14]).

An IoT system will typically involve the use of the sensing layer, communication layer, data-processing layer, and application layer. The sensing layer



measures physical parameters, the gateway layer collects and sends these measurements, software processes the information gathered, and the dashboard presents this information in meaningful form to authorised persons. In case of medical equipment, it is crucial to design the system such that the monitoring will not affect device control functionality. (Ner et al., 2026 [6]; Singh et al., 2026 [8]). These studies concern IoT applications in other settings and are used here only to support general design principles such as sensor-based data collection, secure communication, dashboards and monitoring; they do not establish clinical effectiveness or CT-scanner performance.

2.2 CT SCANNER PERFORMANCE AND QUALITY CONTROL

CT performance is determined using a combination of acceptance testing, quality control processes and further performance assessments. Characteristics of image quality may include CT numbers accuracy, image noise, uniformity, resolution, low contrast detectability and artefacts. Mechanical and operational tests may comprise table motion, positioning, warning and status indicators and condition of associated parts. The frequency and approach of the testing should adhere to the requirements of relevant standards and guidelines, manufacturers' recommendations and the facility's approved quality control program.

The methods for the assessment of CT system performance are provided in the AAPM Task Group 233 report that covers noise, resolution, task based image quality and behaviour of automatic exposure control (Samei et al., 2019) [1]. It states that CT performance should be considered in the context of clinical application and cannot be evaluated using only one specification. It also confirms that the monitoring system should keep trends and context of the values rather than treat each reading separately.

2.3 AUTOMATED MONITORING Of CT QUALITY INDICATORS

With regards to automated CT quality control, studies have shown that the data can be acquired through the CT quality assurance phantom scanning. Important aspects were considered in this process including positioning, image noise, uniformity, homogeneity and water and air CT numbers. The findings showed that automatic evaluation would help identify any issues so that proper measures would be taken (Quality control of CT systems by automated monitoring of key performance indicators, 2015) [4]. This thus supports this framework as it shows how data can be acquired from routine quality control evaluations.

Going forward, an IoT platform can be implemented to acquire information about the state of the equipment, environmental factors and maintenance history. An alert would automatically be sent about any increase in image noise, which would then be investigated together with any previous calibration or servicing alerts. However, this does not provide a causal link between the events. It would however aid professionals in making decisions on whether further actions need to be undertaken. Automatic alerts are not diagnoses but should act as triggers for more investigations. (Singla et al., 2026) [11].

2.4 EQUIPMENT SAFETY AND STANDARDS

CT scanning safety depends on the safety of medical equipment, safety of radiation, proper installation and maintenance. IEC 60601-2-44 establishes safety standards for the equipment, which includes X-ray equipment intended for computed tomography (International Electrotechnical Commission, 2016) [2]. It will ensure the safety of the designed equipment. No impact should be made during design on the essential performance, safety interlocks or authorized functions of the device. Besides, quality control should be done by properly qualified persons in the clinical environment. Technical basis for assessment of CT system performance is described in the AAPM guidelines. But procedures will depend on local regulations and manufacturer guidelines. IoT monitoring is not an alternative to acceptance testing, regular QC, radiation surveying, preventive maintenance or mandatory servicing.

2.5 CYBERSECURITY, PRIVACY AND DATA GOVERNANCE

As connected devices that are capable of being used for medical purposes, they are vulnerable to other potential threats as well. The threats could be posed because of the vulnerabilities arising out of unauthorized access, inadequate passwords or weak password control, unsafe wifi transmission, inadequate software updates or patches and inadequate management of remotely accessed devices. Since security and privacy of systems are a concern within the literature on IoH (Islam et al., 2015) [3], network segmentation, strong login processes, role-based authentication, encryption, adequate update processes,



logging and process of action must be considered. The design of this monitor system must ensure minimum collection of information limited only to equipment related information so as to avoid any collection of patient information and scans wherever possible. In case there is any processing of patient information through this application, the legal basis for the collection of such data needs to be established by the hospital. Besides, measures need to be taken for the security of the access to the data and the period for which the data will be retained must also be considered. (Ather et al., 2026 [10]; Singh & Gupta, 2026 [12]).

2.6 RESEARCH GAP

Nevertheless, there are currently standardised procedures for CT quality control testing that exist. However, there are literature studies that show methodologies for automatic analysis of selected quality control measures. There is general connected monitoring architectures discussed in literature for IoH research purposes. There is an area where further research needs to be done in order to come up with a system that focuses solely on CT quality control, which would include taking into account certain information about the scanner's condition, environmental conditions within the room, quality control trends and scanner maintenance.

3. METHODS

3.1 RESEARCH DESIGN

The methodology adopted within the scope of this paper is that of a descriptive and design-based method. Conceptual design has been carried out based on publicly available information, which provides information regarding the evaluation of the performance of CT scanners, automatic QC monitoring systems, IoT design and medical device safety. This is a proposed future pilot study; hence, no scanning machine was utilized, no data collected and no measurement was made experimentally.

3.2 PILOT STUDY LOCATION AND EQUIPMENT.

The pilot in the future can be conducted at a hospital or imaging center, with only one CT scanner. It would need the approval of the organization, as well as that of the manufacturer. The monitoring system will be composed of environmental sensors with external approval, secure data gateway, local server / approved cloud environment, dashboard software, and user account with access controls. Any existing log or service interface from the scanner will need to be implemented through the manufacturer's documented and approved procedure.

3.3 PARAMETERS TO BE MONITORED

The IoT based monitoring system would monitor different parameters of the CT scanner in order to ensure the proper functioning of the equipment. They would be able to identify issues related to the equipment and help ensure that the images are good quality.

Room Temperature and Humidity – The system would use sensors to monitor the temperature and humidity in the room. It is necessary to maintain proper temperature in the room to enable good functioning of the equipment.

Equipment Status – The status of the CT scanner, whether ready, on standby or faulty, would be monitored by the system. It would help the medical professionals to know the state of the equipment.

Totals Hours and Scans – The total hours and total scans by the CT scanner would be tracked by the system. It would help with scheduling maintenance.

Error Codes – The error codes and faults would be monitored in order to identify issues.

Cooling System – The cooling system would be monitored to identify any issue related to overheating. This would help maintain the working of the CT scanner.

Image Quality – Image quality parameters such as noise, uniformity, accurate CT

Overall monitoring these parameters using IoT technology will aid early identification of issues with the equipment, good image quality, better maintenance scheduling and safe CT scanner operation.

3.4 PROPOSED IOT ARCHITECTURE

It will consist of 5 layers which are:

1.Data collection layer – This layer will collect data and ensure that the data collected is the right one from the environment and equipment that has been



approved. The regular QC values can be manually entered or imported.

2.Gateway layer – Makes sure that the data collected is correct and in the correct format. It should not issue any command or change the scan parameters of the CT scanner.

3.Communication – Makes sure that the data is sent safely within the segmented network. It is necessary that wireless sensors are approved by the hospital IT department.

4.Data storage and analysis – Data will be timestamped and stored. Thresholds will be checked, repeated events identified and trends established. Guidelines should be developed on how long the data will be stored for and backed up.

5.Alert and application layer – Alert dashboard displayed to authorized users. Alerts are triggered using agreed upon guidelines. The alert should have all the necessary details like what parameter, time, source, threshold and the action to be taken.

3.5 DATA COLLECTION

Seek approval from the institution. Talk to the medical physicist, radiology manager, biomedical engineer, manufacturer, and IT/security team.

Establish monitoring log to determine which parameters will be monitored, from where data will be obtained, their units, frequency of collection, threshold values, and responsible party. (Gautam et al., 2026 [14]; Goyal et al., 2026 [13]).

Only those sensors which have been approved can be used. Secure gateway should be set up. Sensors should not create any problems for operation of the scanner or invalidate the warranty of the scanner.

Baseline data need to be obtained during a certain period of time. Baseline data should be evaluated against manufacturer's recommendations and QC thresholds of the facility.

QC data should be obtained regularly using phantom, maintenance should be done. Data needs to be collected in a uniform manner and time stamped.

Look at the dashboard alerts as agreed. Note whether the alerts were valid, false, resolved or referred.

Periodically audit the system for proper access, collection of data, functioning of the system, and managing of alerts.

3.6 ALERT AND ANALYSIS

Alerting should only occur when thresholds have been set in accordance with proper authorization from competent individuals. A basic alerting system could be considered where there would be alerts ranging from low to high. Low level alerts could be used to show informative changes. Medium level alerts can occur when there is a developing trend or one that is close to a threshold. High level alerts would occur when there is a problem that requires immediate attention in line with local guidelines. High alerts should not automatically stop or restart the CT scanner unless it is part of an approved system from the manufacturer. (Sharma et al., 2026) [9].

Analysis will involve descriptive analysis, trend graphs, number of alerts raised per alert, time required to action alerts, downtime and completeness of data. There could be a comparison made for baseline data that exists. This would be before and after implementation. But this must take into account workload and other factors.

3.7 ETHICS, SAFETY AND SECURITY

The monitoring process does not include the patient therefore no ethical approval is needed. But for the case where patient data will be part of the future process of the monitoring system, it will be necessary to have the ethics and privacy approval before collecting the data. Minimal data collection, encryption during data transmission and storage, individual login, role-based access, auditing and a backup strategy should be documented. Remote access from vendors should be restricted to a particular period o

3.8 EVALUATION MEASURES FOR

Technical performance – % of expected data acquired, system availability.

Alarms – Total number of alarms, % of alarms validated as being significant and % of false/duplicate alarms.

Response time – Time to recognize and act on alarms.

Equipment cities: Concept, challenges and realization. International Journal of Technical Innovation in Modern Engineering & Science, 5(Special Issue), 1–6.



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4. RESULTS

Important note: This is a proposed framework paper. No real-world CT scanner was monitored and no experimental dataset was collected. Therefore, the points below are expected outputs and evaluation criteria, not observed or proven results.

4.1 EXPECTED MONITORING DASHBOARD

The proposed dashboard should offer an overview of the status of the scanner operations, conditions of the room, chosen QC variables, and maintenance record. The operator would be able to see the current reading, its time stamp, acceptable operating range, and the trend during previous days/weeks. The visible status indication might assist the staff in distinguishing between normal readings and readings that need further investigation.

4.2 EXPECTED EARLY-WARNING CAPABILITY

Provided that accurate data and professional criteria are used by the system, it can detect recurrent error codes or unusual environmental conditions or changes in the selected parameters. For instance, recurrent cooling warning messages may require a review by engineers. Recurrent changes in measurements of phantom image noise may result in retesting by a medical physicist or re-calibration. These scenarios represent potential alert pathways but they do not mean that a certain failure will automatically result in such alerts.

4.3 EXPECTED DOCUMENTATION AND MAINTENANCE BENEFITS

Time-stamped alarms and maintenance records will provide a more complete history of equipment events. It may enable staff to check if there have been any previous occurrences of the problem, how it has been identified and what the next steps were. It will allow for better communication between radiographers, engineers and medical physicists. It could be that it can assist in planning maintenance work for the department.

4.4 PROPOSED OUTCOMES

The monitoring system, which is proposed to be implemented through the use of IoT technologies, will bring a number of benefits into the process of usage of CT scanners, such as:

Temperature and humidity monitoring in the room. It will enable the identification of any anomalies in the surrounding environment.

Registration of machine work time. It can help plan preventative maintenance activities.

Identification of any often appearing error codes. It will help identify any technical problems at an earlier stage.

Cooling monitoring. Identification of any overheating problems. Protection of key parts of the machine.

Image quality monitoring. Continuous monitoring of the image noise, uniformity and CT numbers. Image quality guarantee.

Radiation monitoring. Monitoring of quality assurance data regarding radiation. It will help assess the performance of CT scanners in terms of safety.

Alert creation. The alerts will be created once any anomaly will be discovered. It will help to take the right actions.

Earlier identification of any issues.

5. DISCUSSION

5.1 INTERPRETATION OF FRAMEWORK

It connects three domains which are usually considered independently. But the key role of the framework does not consist in the replacement of the existing testing process, and it is to provide a model that allows capturing relevant data that enables employees to reveal trends. This is related to the usage of IoT in healthcare. The usage of IoT can increase information accessibility, but there are some security issues that should be taken into account. (Ner et al., 2026 [6]; Bisht et al., 2026 [7]; Goyal et al., 2026 [13]).



5.2 IMPACT ON CT QUALITY ASSURANCE

In order to ensure the quality of a CT scan, reproducibility of data and interpretation by experts are required. Methods used for evaluating CT scanner performance include assessing image noise, spatial resolution, task-based performance, and automated exposure control (Samei et al., 2019) [1]. Using IoT to create a log might help with tracking specific QC data. Nonetheless, only the dashboard itself will not reveal if the scanner is clinically appropriate. Interpretation of the QC data by a medical physicist is required based on the proper test, tolerance, and clinical significance.

There are studies which involve the automatic monitoring of Key Performance Indicators, which may be useful in identifying when there are deviations in routine phantom images. Nonetheless, although the use of this technique may help in quicker identification of deviations, valid data, thresholds, and alerts management system need to be established. In that way, the framework presented relates equipment and environmental data to this concept. Nevertheless, the QC process will not change.

5.3 OPERATIONAL IMPACT

The presence of an integrated system may assist in planning maintenance tasks. It may assist in identifying repetitive problems and equipment usage patterns. Such a pilot may reveal that the personnel are recognizing useful notifications early while delivering appropriate information to service teams. It may assist in effective planning. Potential advantages may involve reducing unnecessary disruption, improving availability of equipment and using engineering workforce most efficiently. Nonetheless, there will be a cost of implementation. It will consist of sensor data collection, network, software licenses, cybersecurity and labor costs.

Conducting a cost/benefit analysis is necessary, taking into consideration the total costs and tangible benefits obtained (such as the downtime, amount of service calls, alert response time and equipment availability). False alerts may lead to extra work for personnel and decrease confidence in the system. Thus, a small-scale pilot with clearly defined criteria for success will be an appropriate start. (Singla et al., 2026) [11].

5.5 LIMITATIONS

This is a conceptual framework document. It does not contain any data regarding sensor precision, data about specific scanners, clinical outcome, penetration testing or cost. The availability of data will depend on the manufacturer and the scanner model being used. The data could be confidential and might only be available using approved service software. Sensors used for environmental monitoring may not give accurate readings about the conditions inside critical regions of the scanner. External monitoring does not substitute for internal monitoring.

The threshold levels will depend on the scanner model, site, load and guidelines from the manufacturer. A poorly designed alert system will lead to unnecessary alerts or miss out on important alerts. Network problems might result in disruption of data. Using the cloud might cause additional privacy and security concerns.

5.7 RECOMMENDATIONS

Begin with some low-risk and non-invasive parameters.

Ensure all relevant written authorizations by the hospital, medical physicist, IT/security department, and manufacturer where applicable.

Ensure the use of only authorized interfaces. Ensure the network being used is separate from the scanner. (Singh & Gupta, 2026 [12]; Sharma et al., 2026 [9]; Ather et al., 2026 [10]).

Determine thresholds, ownership of the alerts, their acknowledgment timeline, and an escalation policy for the same.

Train personnel on alert interpretation and document consistently.

Perform periodic performance reviews. Remove unnecessary alerts.

6.CONCLUSION

An IoT solution may improve the monitoring of the performance of CT scanner and equipment condition. Utilizing validated information about equipment, environment, selected trends for QC, and maintenance data in the secure dashboard will allow for timely detection of any deviations and better communication



between radiographers, medical physicists and service engineers. This concept is intended to help in the context of routine QC procedure and not to interfere with manufacturer's service procedures or radiation safety regulations.

The key points of designing the safe solution include validation of the data sources, approved thresholds, security issues, alert ownership, and separation of the critical functions of the scanner. As this paper is a concept only, a pilot test would be required to evaluate the effect of the developed solution on the alert management, equipment availability and quality management.

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