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Development of a Remote Visitor's Health Assessment and Documentary Model for Coronavirus Applications

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Abstract: *The conceptual model for the remote assessment of visitor's coronavirus infectious status is the focus of this paper. The sudden outbreak of the Coronavirus disease presented serious health challenges globally and the fastest means of detecting the affected persons lies largely on the handheld thermometer device. This instrument detects the temperature within certain range for the virus symptoms diagnosis. The handheld thermometer design is in a short gun format and requires human effort with utmost proximity, which may suggest transfer of the virus to the gun operators as its needs human input before it operates optimally. However, this model considers an intelligent and contactless way of detecting visitors' virus status before allowing access to prevent cross-virus transmission to others. This intelligent device is embedded into the entrance area for remote and automated virus scan. The resultant effect will lead to the development of a visitor's health status assessment scheme embedded into the remote entrance system; an android application for remote monitoring of the entrance and exit of the commuters; database and referrer options scheme via the regulatory agencies. The result for each visitor virus status is wirelessly transmitted and accessed through a mobile application and are documented on the cloud for the disease control agencies. This model is developed for areas such as banks, hospitals and homes. For research advancement, the design should be implemented with incorporated cameras for real time image processing of the visitors/commuters.*

Keywords*: Coronavirus disease, documentary, model, remote assessment, visitor's health****.***

1. INTRODUCTION

1.1 Background

Biomedical Engineering continues to play an important role in the health sector as smart devices are incorporated into our daily activities for coronavirus infection detection. COVID-19, a coronavirus disease was declared a pandemic by World Health Organization following its exponential global spread and requires prompt health detection and documentation schemes [1]. Detection systems such as handheld infrared thermometers were mostly used in airports for travellers, but since the advent of the COVID-19 pandemic, the sensing device is required in every home and public establishment such as banks, hotels, and markets. The reverse transcription polymerase chain reaction (RT-PCR) has been proven to be the suitable clinical option for the virus detection [2].

However, before any medical examination is carried-out on suspected persons to be COVID-19 patients, there should be a smart way of determining the risk probability of persons. Although every household, individual and corporate organization can be made to procure the already existing handheld thermometer for the determination of an individual's temperature which relates to one of the ways of determining coronavirus symptom. Hence, the tendency for the handheld thermometer operator to contact the virus is high due to its close distance measurement approach. There has not been any means of remote detection and reporting of the corona virus disease before now apart from moving around to carry clinical confirmatory test. The absence of human interaction and the interface between humans and an artificial intelligent medium would surmount the possibility of virus infection. The high cost of training and hiring labour for thermometer operation will also be curtailed. This would aid the medical team in their clinical assessment to quickly identify patients suffering from high fevers. In view

of this, the use of the synthetic fibre swap instrument from the nose through the ear with swab for the sample collection would be used as the confirmatory test, and not the predictive test. These reasons necessitated the remote entrance health assessment device which will detect for quick attention to prevent the spread of the virus. This paper proposes a conceptual remote visitor's health assessment and documentary model for coronavirus applications with specific objectives which are: to develop a visitor's health status assessment system embedded into the remote entrance system; to develop an Android application for remote monitoring of the entrance and exit of the commuters; to design a database and referrer options scheme via the regulatory agencies; and to formulate the system validation, evaluation, and data analysis criteria.

This experiment model is targeted at providing the coronavirus detection system embedded into the existing remote entrance device with a delay that prompt the human to wait in a bit for the system to scan its health status without human effort. This proposed model will not incorporate the reverse transcription polymerase chain reaction, but the thermometer device is built into the entrance scheme for the remote health assessment. In addition, an Android application will be developed for remote monitoring of the entrance and exit of commuters. Furthermore, a cloud database will be incorporated with a referrer options scheme for the regulatory and disease control agencies. A critical system performance evaluation and validation using data analysis criteria will be carried out to ascertain the efficiency of the system.

1.2 Impact Statement

This remote embedded thermal device is contactless and requires minimal or no human effort in its operation as compared to the handheld thermometer device already in the use which requires human effort with certain limit which is prone to operator's contagion. Most recently, the thermometer system was modified to provide a standalone system for coronavirus detection purpose in the airports but the size of that design is large and costly to be maintained by an individual or household. Thus, this necessitates the interest of this study which gave rise to this remote visitor's health assessment and documentary model which can achieve the same purpose with or without involving human interface. This remote embedded thermal device is miniaturized in size, cheaper to acquire and easy to install and maintain compared to any known latest coronavirus detection garget to the best of my knowledge. It is believed that, we are in the era of IoT governance and technological advancement. Therefore, this proposed device if approved will in no small way bring a step further in Artificial Intelligent device development as this system is geared toward achieving one of the latest coronavirus gargets at a less cost, reduce size for human portability and convenience. Therefore, this device has been designed to be environment friendly being that is a miniaturized size, has a smaller space to occupy compared to the large sizes available. To this end, this remote embedded thermal health assessment device is not known to this study, had not been seen and reported anywhere in the world at large by any known researcher to the best of my knowledge.

2. LITERATURE REVIEW

Corona Virus 2019 (COVID-19) is a recent global disease discovered in December 2019. The virus is humanly transmitted, wide spread, and was declared a pandemic by the World Health Organization in March 2020. There have been several incidents as reported by most countries of the world of this rapid spread virus. Severe Acute Respiratory Syndrome (SARS) is a viral that is responsible for respiratory sickness that causes coronavirus and is spread through close contact with the affected person [3, 4]. The prompt establishment of a virus status assessment scheme is required to prevent further viral transmission [5]. The body temperature scan is one of the prime tests so far conducted on humans and it is one of the ways of ascertaining the risk probability of coronavirus since a high fever is a symptom that suggests the disease. The body temperature of human, ranges between 97℉ (36.1℃) and 99℉ (37.2℃). The prime symptom of coronavirus is measured through intensive fever up to 100.4℉ (38℃) and above. The quick and fast remote prediction and assessment of the visitors temperature status above (38℃) is inevitable before the clinical confirmatory test and thus, necessary. Another type of symptoms-based screening is carried out using a clinical test called the reverse transcription polymerase chain reaction (RT-PCR) [6].

Although this RT-PCR technique is more accurate than the temperature technique, it usually takes a longer time to complete the process. The fastest virus symptom detection approach was the use of the handheld thermometer gun shown in Figure 1. This device is predominantly used in airport for determining the commuters' virus status and in public places such as banks to check customers' body temperatures. Although the device cannot accurately detect the virus status of a user, it can be used to check for fevers which is a major symptom of the coronavirus. The handheld device proximity to the handheld gun's operator does not conform to the social distance doctrine preached all over the world, since the virus is reported to be physically transmitted.

Figure 1: Handheld thermometer gun [1,6]

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For further virus health status assessment, travellers were made to pass through reverse transcription polymerase chain reaction (RT-PCR) test as a symptoms-based system for screening and testing the COVID-19 status of the commuters. RT-PCR test is a popular method due to its ability to detect and differentiate both symptomatic and asymptomatic coronavirus disease status of the individuals [6]. The suitability of RT-PCR for coronavirus test detection, tracing and studying would be effective and efficient with real-time samples [2]. The approach would serve appropriately since the spread has increased exponentially and isolation laboratories are limited in supply compared to the population size in need of the testing services. These would help in determining the virus status through diagnoses using nuclear-derived approach. In these techniques, the virus is detected with its specific genetic material. The clinical samples are obtained for examination from the respiratory track which includes the sputum, nose and throat. The sample is obtained by inserting a synthetic fibre swab which is at least 6 inches long through the nose or mouth to reach in between Nasal passage and Nasopharynx to stop at the resistance area, where the swabbing is carried out to obtain the sample for clinical examination as shown in Figure 2.

Figure 2: Real time reverse transcription polymerase chain reaction (RT-PCR) clinical test [2,3,6]

The sample collected is carried with or without viral transport medium. These specimens contain bat-derived from severe acute respiratory syndrome (SARS)- associated COVID samples which use the synthetic nucleic acid approach. This was widely deployed to health agencies as the clinical confirmatory option [7]. Several works exist in the area of coronavirus detection. The thermometer for individual home temperature sensing is adequate for coronavirus detection and reporting [8]. Similarly, a coronavirus detection scheme with IoT enabled system for rapid virus detection and quick identification are the challenges among others in the fight against coronavirus spread [9 -11].

In addition, the lack of self-testing and sensing device leads to the rapid spread of coronavirus. And these recommend the need for intelligent symptom detection and tracking system development. The transferrable evolving diseases would be detected at the early stage and its prompt attention would curb further disease transmission [12,13]. Further to this, a smart helmet-based internet of things system for coronavirus detection via diagnosing alongside with thermal device has since been proven to be the commonest means of determining corona virus patient. However, the pedestrian's helmet-thermal device with IoT capability and thermal camera was also proposed for pedestrian's image processing [14].

Coronavirus can be detected and diagnosed using smart glass and internet of things. The researcher also proposed the use of drone-based system for detecting and diagnosing coronavirus as the rapid response handling measures [14, 9]. This design also proposed a smart door system for health care assessment as it would give fast and easy coronavirus detection in every home, offices and public places at their entrance and exit points. Security monitoring and control in homes, offices and public places find its application with smart door system via internet of things and has uncovered so many hidden traits with its motion sensing and detection scheme. Application of smart door (internet of thing enabled door system) would aid in remote access control operations [15-21].

Image detection and processing have played a significant role due to its ability to differentiate smartly between object and human. Smart systems sometimes incorporate image processing to analyse and identify objects, as well documented information obtained from those images [22]. Remote sensing and image processing have been of tremendous use to mankind as it helps in the event of identification of object and human in public and private places [23]. The recognition of image in homes and other related places is vital considering today's security trait and could be suitable for healthcare monitoring and control [24]. Image capturing, processing and internet data transmission and documentation would aid the validation of the information gathered by the device [16].

The pre-coronavirus, coronavirus and post-coronavirus pandemic require a formidable and sustainable detection scheme. This scheme would facilitate quick pedestrians/visitors' coronavirus status discovery thereby leading to prompt medical attention. The development of this symptom detection device incorporates smart door system, thermal sensing system, images processing and IoT documentary scheme. This developed device is not a therapy system like Telemedicine system which was designed for distance therapy [25-31]. The advantage of this health assessment scheme over telemedicine device is that it aids in the fast establishment of the visitor's coronavirus symptom status and reporting for further medical attention and not a therapy system application.

For the sustainability and avoidance of the reoccurrence of this global pandemic, a formidable virus detection system is required in every home and public establishment such as restaurants, banks, schools, and markets. This would serve as the first step in detecting the affected persons and isolate them from public places as precautionary measures. Mounting sensing devices on the entrance of the premises with little or no human control would prevent virus transmission due to the absence of physical contact.

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3. METHODOLOGY

3.1 System Description

The health assessment device is embedded into the smart door system at a certain proximity, the visitor's presence is sensed with a delay time and the door will automatically open after the health sensor has captured the visitor's health data (body temperature). If the visitor's temperature is detected to be above 38℃, the door will intelligently not open for the visitor and he/she will be alerted to leave the premises. If the visitor remains within the device confinement after certain interval of time, a health alarm will be activated to inform the disease control authority. These activities are monitored remotely with Android application via a cloud service. Android app is a software application running on the Android platform. The Android platform is built for mobile devices, a typical Android app is designed for a smartphone or a tablet PC running on the Android OS. The block diagram of the system architecture is shown in Figure 3 while the flowchart of the system operation is presented in Figure 4.

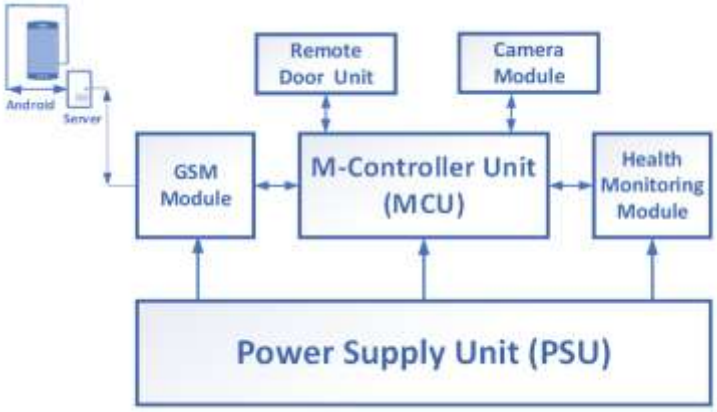

Figure 3: The proposed coronavirus remote visitor's health assessment architecture

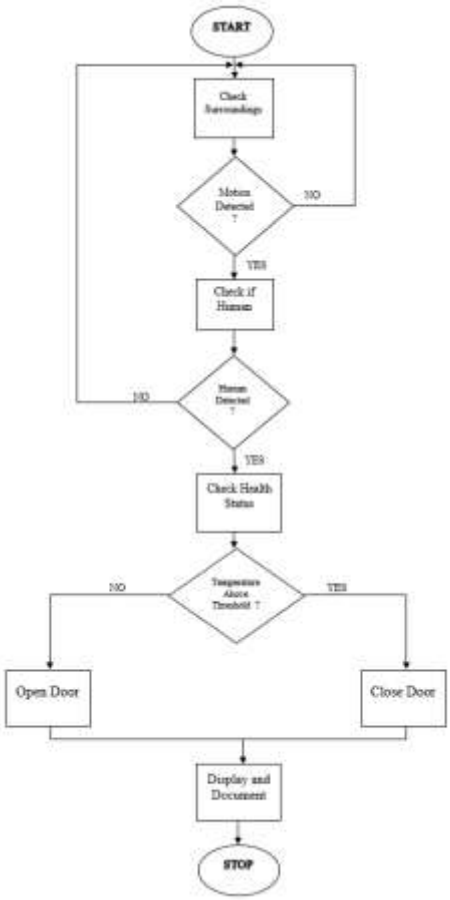

Figure 4: Coronavirus remote visitor's health assessment flowchart

3.2 Hardware Design Specifications

The proposed Coronavirus Remote Visitor's Health Assessment Architecture has five units:

3.2.1 The power supply unit: This supplies the entire system with DC power.

3.2.2 The GSM module: This unit relates the microcontroller decision to the Android through the web for documentation.

3.2.3 The health-monitoring module: This unit contains the thermometer device for remote temperature scan and ultrasound sensor for detection of human presence.

3.2.4 The automatic door unit: This has the motor, relay and position sensor for the detection of human presence before scanning process and for automatically opening or closing of the door.

3.2.5 The Microcontroller unit: This unit intelligently coordinates the GSM module, Health Monitoring module, automatic door unit with the power supply provided in (3.2.1).

Figure 5 shows the circuit diagram of the system with the connections between the various components. The following components are used in the development of the system: Arduino Uno Board; Seven segment display: 4033 seven segment decade counter; Liquid Crystal Display; PIR Sensor; L298N Motor Driver Module; Motor; Connecting wires; 9v DC battery; Voltage regulator LM7805; Temperature sensor LM35; Camera Module and Microcontroller: Atmega328P

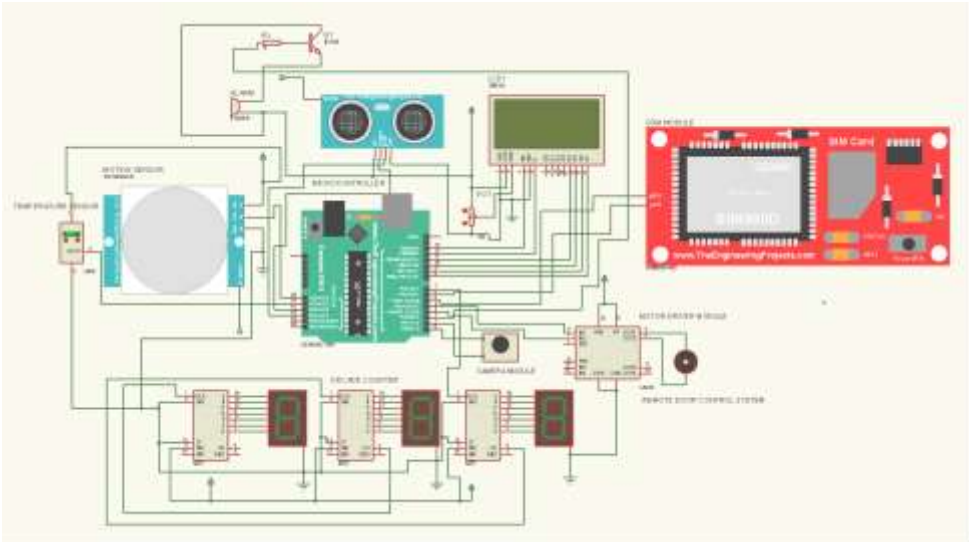

Figure 5: Coronavirus remote visitor's health assessment circuit diagram

In Figure 5, the health assessment device incorporates a real time image processing camera mounted at the entrance alongside with coronavirus detection gadget embedded into the smart door system. When the proximity sensors detect movement and the camera verifies that it is a human, the temperature sensor will capture the visitor's body temperature. If the visitor's temperature is detected to be above 38℃, the door will intelligently not open for the visitor and he/she will be alerted to leave the premises. If the visitor remains within the device confinement after certain interval of time, a health alarm will be activated to inform the disease control appropriate quarters. These activities are monitored remotely with Android application via a cloud service. The smart system has a decade counter system, which records the numbers of commuters that have successfully been scanned for the virus status. The seven segments display the data visibly on the device and the android application also displays the data using its graphical user interface.

3.3 Software Design Considerations

The programming of the microcontroller was done using the Arduino Integrated Development Environment (IDE). The circuit simulation and design will be achieved using the Proteus Suite (version 8.1) from Labcenter Electronics. Sublime text editing platform is used for the JavaScript, Cascade Styling Sheets (CSS) and Hyper Text Mark-up Language (HMTL) script writing and provides the soft-screen graphical user interface on the android application. The database is designed with MYSQL for data storage.

4. RESULTS AND PERFORMANCE EVALUATION

4.1 Proposed System Overview

The proposed visitor's health assessment and documentation system are presented in Figure 6. The system will be mounted in front of the entrance. When the proximity sensors pick up movement, the camera module will determine if the motion came from a human or not using the image-processing algorithm. When a human is detected, the body temperature will be determined using the temperature sensor. The door will be opened (or not) depending on if the temperature level is

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above or below the specified threshold. The documentation module will be operating simultaneously with the assessment module by storing the acquired data into a cloud database.

Figure 6: Proposed pictorial view of the system

4.2 Mobile Applications Interface

The Android application interface for the proposed system is presented in Figures 7 and 8. The application will be accessed by disease control and health officials to analyzed the data acquired from the module. These data can be used for situation reports, preparatory measures, and statistical analysis. The application will provide user registration for new operators and a login page for existing users as shown in Figure 7.

Figure 7: The Android signup/in page

Figure 8: The Android graphical user monitoring and control interface

Figure 8 shows the dashboard representation of the graphical user interface for the Android application. This area will provide an overview of existing statistics and data captured by the system. The proposed database for information storage is

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shown in Table 1. The table consists of the door label, symptom status showing if the temperature is above or below the threshold, the temperature reading, and the captured image of the visitor.

Table 1 shows the corona virus status documentary. Entailed in the database are dates, three entrances A, B, and C of the images captured and the corona virus 2019 status of the person accessing the entrance.

Table 1: Proposed Database for Information Capture

Date / Serial Number	Door Entrance			Symptom Status		Temperature Reading	Image
	A	B	C	Yes	No		
15th May 2020 (1)	Yes	=	=		No	35.7^0	
15th May 2020 (2)	=	Yes	=	Yes	=	40^0	

4.3 The Image capturing functionality of the proposed system

The image processing module will analyse real time images of the entrance point. The module will be used to identify only humans passing through the point. The use of motion sensors alone might result in the triggering of the scanning module even if an animal passes the sensor. To avoid this false detection, the image processing module serves as a second layer of authentication which confirms that it is a human being that passes through the entrance. Once the module identifies and authenticates that a human is passing, the scanning operation will be triggered.

The image-processing module will incorporate the use of Speeded-up Robust Features (SURF) extraction. This technique is used due to its speed, robustness, and improvement over the SIFT algorithm. Figure 9 presents the SURF identification process carried out in MATLAB. After the input image is acquired, the image will be converted to grayscale after which the SURF points will be identified. Based on the extracted features, the system will determine if the visitor is a human or not.

(a) (b) (c)

Figure 9: (a) Captured image (b) Grayscale image (c) Image with SURF points identified

4.4 Documentary Database and Referrer's Option

Table 1 shows the data documentary of the proposed remote visitor's health assessment and documentary Model for coronavirus applications. Whenever the symptom status records "Yes" and the temperature reading exceeds the threshold as mentioned above, the system activates the medical referrer's option and sends the data with the corresponding image to the disease control agency for prompt attention.

5. DISCUSSION

From the results in section (4.4), the proposed model is developed to provide high level of symptoms detection and preventing measures towards corona virus spread from person to another**.** The model detects human presence, and distance; captures human temperature and image; processes the images and determines whether to accept the or deny the visitor access in order not to spread the virus. On completing the process cycles, the visitor's details are documented on cloud through its android application. The thermal handheld sensor was recommended for home use as a single device due to its ability to detect virus symptoms [8,1,6].

The introduction of this embedded system with remote data assessment via internet of things is advocated as it validates the authentication functionalities of the proposed system [9]. Thermal handheld gun for visitor's temperature captured as suggested for domestic use was made to function with the IoT remotely [1].

The developed embedded smart door system for coronavirus application has inbuilt motion, temperature and proximity sensor but this design is embedded into the remote smart door system as against their singular purpose design [9, 15-21, 24]. The motion sensor detects the presence of an object, the ultrasonic sensors determine how close it is to the entrance system, if it is at the design distance limits**,** and the image captured by the camera is processed. The image captured is extracted by the Speeded-Up Robust Features (SURF) algorithm and it is processed using Matlab within some microseconds. Different layers of authentication for a particular visitor are carried out before sending the data for documentation in real time data processing.

The data assessed from the system are documented in respect of the visitors and sent to the disease control agencies. The system is capable of identifying false object/image from its scanned image through image processing. The disease control agencies and an approved operator of a particular entity can log onto the mobile or web applications, the information of the visitor would be seen, the visitors may be allowed access to where he/she wants to enter depending on their respective prevailing data [9 -11].

The height of individuals varies and as such, this design considers multiple thermometer gun placement because its embedded multiple sensory capability at varying degree of positions. Further to this, this multiple thermometer gun is calibrated to give a single aggregate readable value at every measurement unlike a single handheld thermometer gun available in the market [1,6,8].

The performance of the human identification with image processing algorithm has accurate precision in that it can identify false images, and differentiate similar images as well [14]. The computational complexity in human image identification, authentication and processing are managed by the system controller with the help of a microcontroller action of multi-tasking, high-speed and accuracy. Thus, this system guarantees prompt visitor corona virus status assessment and documentary through the android application to explore fast approach of managing the person's ailment as well as prevent virus spread against the backdrop of close contact [3-5].

6. CONCLUSION AND FUTURE WORK

The conceptual design of a remote visitor's health assessment and documentary model for coronavirus applications was presented in this study. The resultant effect will lead to the development of a visitor's health status assessment scheme embedded into the remote entrance system; an android application for remote monitoring of the entrance and exit of the commuters; database and referrer options scheme via the regulatory agencies. The result for each visitor virus status was wirelessly transmitted and accessed through an android application, and documented on the cloud for the disease control agency to access. The thermometer entrance embedded model capable of measuring the visitors / commuter's coronavirus status was designed. This was achieved by scanning the visitor's temperature intelligently if the temperature is within the acceptable range of 97°F(36.1℃) to 99°F(37.2℃) , shows that the visitors or the commuters is risk free and if the device record gives the temperature above 100.4°F(38℃) , the instrument reveals that there is a trace of coronavirus symptoms in the person. This automated entrance system with its temperature comparative capability is able to allow or hinder the visitor access by opening or closing the intelligent door system since the simulation reveals that the image of the visitors could be captured with the incorporated cameras and the real time image processing of the visitors/commuters could be obtained. With the proposed system, homes, hospital, banks, churches, mosque, stadium and airports can achieve verification or screen for coronavirus symptoms in a non-contact mode. For research advancement, the proposed system should be implemented with incorporated cameras for real time image processing of the visitors/commuters.

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