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Smart genetics for smarter health

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Abstract: The most important part of a city is the people who live in it. Therefore, wellness and health are indispensable for the Smart Cities concept. In this paper, we introduce an approach that combines genetic research with environmental monitoring in real time by using an integrated system of IT and IOT that helps to understand better and prevent diseases, improving the quality of life of the citizens. We are working to develop a virtual platform that creates and establishes correlations between the genetic information of the user and their environment. The principal advantages of this project are to allow health care providers, governments and citizens to make smarter decisions oriented to health care, implementing Health Information Technologies (HIT) and improving the concept of Mobile Health (mHealth), all of these based on the Quadruple Helix Innovation model.

Keywords—genetics, HIT, smart health, predictive modelling, smart cities

1. Introduction

There are several activities and approaches being applied to help reduce the reproduction rate of COVID-19. These include self-isolation methods such as working from home, improved basic hygiene such as increased hand washing and the deployment of personal protective equipment (PPE) to reduce the prospect of infection.

Smart and connected health care is of specific significance in the spectrum of applications enabled the Internet of Things (IoT). Networked sensors, either embedded inside our living system or worn on the body, enable to gather rich information regarding our physical and mental health. In specific, the accessibility of information at previously unimagined scales and spatial longitudes combined with the new generation of smart processing algorithms can expedite an advancement in the medical field, from the current post-facto diagnosis and treatment of reactive framework, to an early-stage proactive paradigm for disease prognosis combined with prevention and cure as well as overall administration of well-being rather than ailment. This paper sheds some light on the current methods accessible in the Internet of Things (IoT) domain for healthcare applications. The proposed objective is to design and create a healthcare system centred on Mobile-IoT by collecting patient information from different sensors and alerting both the guardian and the doctor by sending emails and SMS in a timely manner. It remotely monitors the physiological parameters of the patient and diagnoses the illnesses swiftly.

As there are the frequent contact comes with patient in corona ward there might be chances to be corona to health worker so that were proposed a system which will work on the evaluation of such system which automatically whole data from sensor connected to body of patient and monitor if any up comes or risk occur it will show the alert to doctor.

1.1 Motivation

An essential part of the present world society is the aging population of the world. The average life expectancy has substantially increased as the mortality rate has considerably decreased significantly because of the global advancements in economy, society and healthcare over the past few decades. As a direct outcome, the number of older people across the world has steadily increased. The average percentage of elderly people in the world today (person aged 65 or older) is 7 percent [1]. Furthermore, the percentage of adults over the age of 65 in many nations outpaces the global average, such as 18.5 percent in Finland, 18 percent in Sweden and 15 percent on average for nations in the Organization for Economic Co-operation and Development (OECD) group. This percentage is also expected to increase in the near future. It is anticipated that by the year 2050, 24 percent of the world population of Sweden will be senior citizens, 10 percent of whom will be 80 or more [2].

IoT based technology can deliver a substantial amount of information regarding human, appliances, medical devices, and others. The combination of modern internet technological advancements and IoT provides a great deal of innovative products and services based on wireless communication using low-cost sensors [3]. It offers more collection and processing of data and other services. Any object connecting to IoT demands a unique IP address or mode of identification that can be attained using IPv6.

There exists still several people around the globe whose health is affected by the lack of adequate access to hospitals. Wireless alternatives connected to Internet of things can enable remote monitoring of patients rather than visiting the hospital due to the latest wearable technology. A wide range of sensors that are attached to a patient's body could be used to securely obtain patient data, and the data collected can be examined and sent to the main server using various modes of transmission (3G/4G or Wi-Fi) [4]. All doctors have access to the data and can view the data, and decide accordingly on the type of treatment to provide. People acknowledge that health and well-being is the fundamental condition for promoting the economic development with the passing of time and the development of the society. Most people claim that in terms of time, the current public healthcare system and its support were challenged considerably. Globally, government and the private sector are continuing to invest billions for the development of IoT devices, some of which include the Ministry of Industry and IT's National IoT Plan for China, the European Research Cluster on IoT (IERC), Japan's u-Strategy, UK's Future Internet Initiatives, and Netergit's National Italian Project [5]. Medical and health care IoT applications will benefit the patients significantly by using the finest medical assistance, the fastest treatment time, the most satisfactory service and the lowest medical costs.

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1.2 Objective

- To develop and implement health emergency condition prediction based on Machine Learning approach.
- To implement auto prediction system for reducing the risk of doctors and nurses in CORONA hospital.
- To monitor the live data and apply enhance emergency prediction.
- Interactive alert system with integration
- To integrate the system with diet plan recommendation for the patients with specific and more vulnerable chronic medical conditions.
- To help in monitoring patients from anywhere and anytime.

Smart and connected health care is of specific significance in the spectrum of applications enabled the Internet of Things (IoT). Networked sensors, either embedded inside our living system or worn on the body, enable to gather rich information regarding our physical and mental health. In specific, the accessibility of information at previously unimagined scales and spatial longitudes combined with the new generation of smart processing algorithms can expedite an advancement in the medical field, from the current post-facto diagnosis and treatment of reactive framework, to an early-stage proactive paradigm for disease prognosis combined with prevention and cure as well as overall administration of well-being rather than ailment. This paper sheds some light on the current methods accessible in the Internet of Things (IoT) domain for healthcare applications. The proposed objective is to design and create a healthcare system centered on Mobile-IoT by collecting patient information from different sensors and alerting both the guardian and the doctor by sending emails and SMS in a timely manner. It remotely monitors the physiological parameters of the patient and diagnoses the illnesses swiftly.

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2. Literature Survey

Nitin P. Jain, et. al, presents An Embedded, GSM based, Multiparameter, Realtime Patient Monitoring System and Control – An Implementation for ICU Patients. In the implemented system a reliable and efficient real time remote patient monitoring system that can play a vital role improvising better patient care is developed.

Hasmah Mansor, et.al proposed a Body Temperature Measurement for Remote Health Monitoring System. Remote health monitoring system has been an interesting topic recently among medical practitioners, engineers as well as IT professionals. However, the application of remote health monitoring system where doctors can monitor patients' vital signs via web is practically new in Malaysia and other countries.

Barger et al. [3] made a smart house facility using a sensor network to monitor and track the movements of the patient in hoke and a prototype of the same is also being tested. The primary objective of their work is to check if their system is capable to outsmart the behavioural patterns and have discussed about the same in their work.

Purnima, et. al, presents an Zigbee and GSM Based Patient Health Monitoring System Care of critically ill patient, requires spontaneous & accurate decisions so that life-protecting & lifesaving therapy can be properly applied. Statistics reveal that every minute a human is losing his/her life across the globe.

Dwivedi et al. [5] developed a framework in order to secure the clinical information that has to be transmitted over the internet for Electronic Patient Record (EPR) systems in which they propose a multi-layered healthcare information system framework which is a combination of Public Key Infrastructure, Smartcard and Biometrics technologies.

Gupta et al. [6] proposed a model which measures and records ECG and other vital health parameters of the patient using Raspberry Pi and can be of a great use for the hospitals and patients as well as their family members.

Nagavelli and Rao [9] proposed a novel method to predict the severity of the sickness from the patient's medical record using mining based statistical approach which they said as degree of disease probability threshold. And in order to meet their goal they have revamped an0 algorithm that is mostly needed to derive the hyperlink weight of the websites.

Lopes et al. [8] proposed a framework based on IoT for the disabled people so as to study and find the IoT technologies in healthcare segment that can benefit them and their community. They took two use cases to study the latest IoT technologies and its application that can be used mainly for the disabled people.

Sahoo et al. [10] studied the healthcare management system and about the large amount of patient data that is generated from various reports. They further analyzed the health parameters to predict the future health conditions of the patient or the said subject. They use a cloud based big data analytic platform to achieve the same using the means of probability.

Tyagi et al. [11] explored the role of IoT in healthcare and studied its technical aspects to make it reality and identify the opportunities for which they propose a cloud based conceptual framework in which the patients' medical data and information can be securely transferred, with the permission of patient and their family by building a network among patient, hospital, doctors, Labs etc. The primary reason behind this is to relieve patient from the expensive clinical aid, overcome the shortage of doctors and therefore providing enhanced care and service to patients.

Chiuchisan et al. [4] proposed a framework to prevent the threats to patient in smart ICUs. The proposed system intimates the patient's relatives and doctors about any inconsistency in their health status or their body movements and also about the atmosphere of the room so that the necessary precautionary measures can be taken. Objectives: The study reported in this article aimed to identify: (i) the most relevant applications supported by smart city infrastructure with an impact on the provision of healthcare; (ii) the types of technologies being used; (iii) the maturity levels of the applications being reported; and (iv) major barriers for their dissemination. Methods: A systematic review was performed based on a literature search. Results: A total of 44 articles were retrieved. These studies reported on smart city applications to support population surveillance, active ageing, healthy lifestyles, disabled people, response to emergencies, care services organization, and socialization. Conclusions: Most of the included articles were either of a descriptive and conceptual nature or in an early stage of development, which means that a major barrier for their dissemination is their lack of concreteness. Keywords: smart city; smart living; healthcare; population surveillance; response to emergencies; active ageing; healthy lifestyle 1. Introduction Smart cities promote the integration of traditional urban infrastructures and information technologies (IT) including Internet of Things (IoT) sensors to allow cities to succeed socially and economically as well as provide high quality and sustainable urban services [1,2]. To do so, smart cities require cooperation between the public and private sectors to implement and deploy IT platforms capable of collecting and analysing the vast quantities of data required by automated and intelligent processes [2,3]. According to the literature, a set of characteristics have been identified as relevant in the context of smart cities [3–5]: smart economy—competitiveness of the economy, which is influenced by factors such as innovative spirit, entrepreneurship, ability to transform or integration in the international market; smart mobility—local, national, and international accessibility, and the availability of communication infrastructure or sustainable and safe transport systems; smart governance—political strategies and perspectives, transparent governance, participation of the individuals in public life, and the quantity and quality of public services; smart environment—the ecological awareness and sustainable management of natural resources including environmental conditions such as air quality; smart people—social and human capital such as the level of qualification, fostering lifelong learning, ethnic plurality, and open Technologies 2019, 7, 58; doi:10.3390/technologies7030058 www.mdpi.com/journal/technologies Technologies 2019, 7, 58 2 of 16 mindedness; and smart living—quality of life of the individuals, namely health conditions, cultural and education facilities, housing quality, and touristic attractiveness. Although there is a significant number of systematic reviews related to healthcare provision supported by IT (e.g., [6–10]), to the best of the authors' knowledge, systematic reviews of the literature related to the implementation of smart cities are scarce and address specific aspects (e.g., [11–13]). Since systematic evidence is required to inform smart city stakeholders and researchers about state of the art solutions, the systematic review reported by the present article aimed to identify the most relevant applications supported by smart city infrastructure with an impact in the provision of healthcare, which is a relevant component of smart living. 2. Materials and Methods Systematic reviews and meta-analyses have become progressively important in healthcare and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement has been widely used either to investigate cost-effectiveness, diagnostic or prognostic questions, or policy making issues [14]. This systematic review followed the PRISMA guidelines since the general concepts and topics covered by PRISMA are all relevant to any systematic review, not just those whose purpose is to recap the benefits and harms of a healthcare intervention. For the specific objective of the systematic review reported by in this article, the following research questions were considered: • RQ1: What are the most relevant application domains? • RQ2: What are the types of technologies being used? • RQ3: What are the maturity levels of the applications being reported? • RQ4: What are the major barriers for the dissemination of the applications being reported? Boolean queries were prepared to include all articles published before 31 December 2018 that had in their titles, abstract, or keywords at least one of the following expressions: 'Smart City', 'Smart Cities', 'Smartcity', 'Smartcities', 'Smart-city', and 'Smart-cities'. The resources searched were two general databases, Web of Science and Scopus, and one specific technological database, IEEE Xplore. The literature search was performed in March 2019. The option of carrying out a comprehensive initial survey on smart cities (i.e., without keywords to filter articles related to healthcare applications) was considered to minimize the possibility of not retrieving relevant studies, to clarify the importance given to issues related to healthcare applications within smart city publications, and also because the boundaries between the various definitions of what can go into the generic definition of healthcare applications and categories such as m-health or e-health are not yet completely defined and stable. As inclusion criteria, the authors aimed to include all of the articles published in scientific journals or in conference proceedings that reported evidence of explicit use of applications requiring smart city infrastructure with an impact in the provision of healthcare in the context of smart cities. First, the articles were classified according the generic categories of smart cities: smart economy, smart mobility, smart governance, smart environment, smart people, and smart living [3–5]. Subsequently, articles classified as smart living were selected and analyzed since the main objective of this systematic review was to identify applications supported by smart city infrastructure with an impact in the provision of healthcare, which is a relevant component of smart living. Finally, the articles reporting the use of applications with an impact in the provision of healthcare were selected. Considering the exclusion criteria, the authors aimed to exclude all the articles not published in English, without abstracts or without access to the full text. Furthermore, the authors also aimed to exclude all articles that reported on overviews, reviews, and applications that did not explicitly require smart city infrastructure, or that were not relevant for the specific aim of this study. After the removal of duplicates and articles without abstracts, the analysis of the remainder of the articles was performed according the following steps: Technologies 2019, 7, 58 3 of 16 • First, the authors assessed all titles and abstracts for relevance and those clearly outside the scope of applications related to smart cities (independently of being or not related to healthcare provision) were removed. • Then, the abstracts of the retrieved articles were assessed to verify if they were related to smart living, which included health conditions. Articles reporting studies not related to smart living were excluded. • Afterward, the abstracts of the remaining articles were assessed and those not reporting the use of applications with an impact in the provision of healthcare where excluded. • Finally, the authors assessed the full text of the retrieved articles according to the outlined inclusion and exclusion criteria and classified them. This classification was performed by using a synthesis process based on the method proposed by Ghapanchi and Aurum [15] (i.e., terms and definitions used in the included articles were identified to create a primary list of application domains, which were later refined by further analyses). Regarding the classification of the articles, it should be noted that at the outset of the procedure, to harmonize criteria among the various authors, a group of 100 articles were randomly selected, which each of the authors individually classified. This categorization was later checked and discussed as a group, which allowed the stabilization of the criteria for the allocation of a given category to each reference. In addition, during the whole classification process, there were bimonthly meetings to clarify any doubts. In all of these steps, the articles were analyzed by at least two authors and any disagreement was discussed and resolved by consensus. 3. Results This systematic review followed the PRISMA guidelines [14] and Figure 1 presents the respective flowchart. Technologies 2019, 7, x FOR PEER REVIEW 3 of 15 • First, the authors assessed all titles and abstracts for relevance and those clearly outside the scope of applications related to smart cities (independently of being or not related to healthcare provision) were removed. • Then, the abstracts of the retrieved articles were assessed to verify if they were related to smart living, which included health conditions. Articles reporting studies not related to smart living were excluded. • Afterward, the abstracts of the remaining articles were assessed and those not reporting the use of applications with an impact in the provision of healthcare where excluded. • Finally, the authors assessed the full text of the retrieved articles according to the outlined inclusion and exclusion criteria and classified them. This classification was performed by using a synthesis process based on the method proposed by Ghapanchi and Aurum [15] (i.e., terms and definitions used in the included articles were identified to create a primary list of application domains, which were later refined by further analyses). Regarding the classification of the articles, it should be noted that at the outset of the procedure, to harmonize criteria among the various authors, a group of 100 articles were randomly selected, which each of the authors individually classified. 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Title and abstract screening—Step 3: excluded articles (n = 6109). Title and abstract screening—Step 4: excluded articles (n = 485). Figure 1. Flowchart of the systematic review. Technologies 2019, 7, 58 4 of 16 A total of 11,321 articles were retrieved from the initial search on the Web of Science, Scopus, and IEEE Explorer (identification phase). The initial step of the screening phase (i.e., Step 1 of the title and abstract screening) yielded 11,228 articles by removing duplicates (81 articles) or articles without abstracts (12 articles). Based on the titles and abstracts (i.e., Step 2 of the title and abstract screening), 4501 articles were removed due to the following reasons: (i) article not published in English (17 articles); (ii) was an overview or review (421 articles); (iii) were editorials, prefaces, and announcements of special issues, workshops, or books (113 articles); or (iv) were not related to applications for smart cities (3950 articles). Afterward, the abstracts of the remaining 6727 articles were analyzed and it was concluded that only 618 articles were related to smart living (i.e., Step 3 of the title and abstract screening). Of these 618 articles, 485 were excluded because although they were related to smart living, they were not specifically related to the health conditions of the individuals (i.e., Step 4 of the title and abstract screening). Considering the 133 remaining articles, it was not possible to access the full texts of five articles, hence they were excluded from this analysis. Furthermore, 84 articles were excluded since they were not relevant for the specific aim of this study (e.g., articles reporting overviews, articles reporting the development of applications that did not require smart city infrastructure, or articles reporting the development of support technologies and not specific applications for smart cities). From the retrieved 44 articles, 34 were published in conference proceedings and only 10 were published in scientific journals [16–25]. After the respective analyses, these articles were divided into the following application domains: population surveillance; active ageing; healthy lifestyles; support to disabled people; response to emergencies; care services organization; and socialization. Figure 2 presents the number of articles found in each application domain. Technologies 2019, 7, x FOR PEER REVIEW 4 of 15 A total of 11,321 articles were retrieved from the initial search on the Web of Science, Scopus, and IEEE Explorer (identification phase). The initial step of the screening phase (i.e., Step 1 of the title and abstract screening) yielded 11,228 articles by removing duplicates (81 articles) or articles without abstracts (12 articles). 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Number of articles per application domain. 3.1. Application Domains 3.1.1. Population Surveillance According to ([26], p. 164), population health surveillance is the "ongoing systematic collection, assembly, analysis, and interpretation of population health data, and the communication of the information derived from these data to stimulate response to emerging health problems, and for use in the planning, implementation, and evaluation of health services and programs". Since IT facilitates the implementation of practical and efficient mechanisms to gather data, 14 of the retrieved articles reported on studies to support data collection, analysis, and dissemination applied to surveille diseases [27], accidents [28], environmental conditions [16,25,29,30], physical activities [31], emotions [17,32–61], and food quality [37]. Figure 3 presents the articles found for each topic. Figure 2. Number of articles per application domain. 3.1. Application Domains 3.1.1. Population Surveillance According to ([26], p. 164), population health surveillance is the "ongoing systematic collection, assembly, analysis, and interpretation of population health data, and the communication of the information derived from these data to stimulate response to emerging health problems, and for use in the planning, implementation, and evaluation of health services and programs". Since IT facilitates the implementation of practical and efficient mechanisms to gather data, 14 of the retrieved articles reported on studies to support data collection, analysis, and dissemination applied to surveille diseases [27], accidents [28], environmental conditions [16,25,29,30], physical activities [31], emotions [17,32–61], and food quality [37]. Figure 3 presents the articles found for each topic. Technologies 2019, 7, 58 5 of 16 Technologies 2019, 7, x FOR PEER REVIEW 5 of 15 Figure 3. Number of articles found for each topic of the population surveillance domain. In terms of disease surveillance, [27] proposed a technological architecture that could be used to allow individuals to send their health data without disclosing their identity, which might be useful for real-time urban scale virologic and epidemiological data monitoring. Concerning accident surveillance, [28] proposed a data analytics algorithm to predict and reduce the impact of traffic accidents and uncover important patterns. Relevant data for analysis were received by the Office of the Traffic Commissioner at Bangalore and included the type of accident, light condition, severity, speed zone, and alcohol consumption. Regarding the monitoring of environmental conditions, four articles were retrieved: [16] proposed the development of an application to monitor the index of electromagnetic radiation of buildings and areas of a smart city, dedicated to individuals who suffer from the pathology of electromagnetic hypersensitivity; [25] was based on a scoping review and suggested a micro-level monitoring network of static devices that could measure harmful air pollutants and ultraviolet radiation exposure levels with the aim to prevent lung cancer and skin cancer, respectively, by improving air quality and reducing ultraviolet exposure; [29] proposed an application to monitor individual environments (e.g., infrastructure, weather, or social interactions) to better understand the link between genetic traits and disease by using genome-wide association studies; and [30] presented a mobile application to estimate the level of ultraviolet radiation exposure each individual was subjected to at any given time and location. Regarding the surveillance of physical activities, [31] described distinct types of fitness sensor applications and presented a conceptual architecture for data collection and aggregation as well as the types of secondary uses for these collected data within smart cities. In terms of emotion surveillance, six articles were explored [17,32–36]: [17] proposed a webbased portal through which individuals could provide personal details (e.g., age, gender, or household income) together with their feelings of wellbeing; [32] provided an overview of the relevant affective states and showed how they could be detected individually and then aggregated into a global model of affect, which could be used to promote an affect–aware city; [33] presented a smartphone application that analyzed individuals' emotions and their relation to different city areas; [34] attempted to map and correlate large-scale sentiment data to urban geography features, and consequently endeavored to understand the main sources of happiness in the city landscape; [35] explored various pre-processing methods to assess how they affected the performance of Twitter sentiment classifiers; and [36] aimed to present an ambient geographic information (AGI) approach to assemble geo-tagged data related to an individuals' perception and feelings about a city from Twitter, Flickr, Instagram, and Facebook. Finally, concerning food quality surveillance, [37] presented a low-cost cooperative monitoring application based on an electronic nose tool to be used in farms to allow, in real-time, for the monitoring of gas concentrations in raw milk. Figure 3. Number of articles found for each topic of the population surveillance domain. In terms of disease surveillance, [27] proposed a technological architecture that could be used to allow individuals to send their health data without disclosing their identity, which might be useful for real-time urban scale virologic and epidemiological data monitoring. Concerning accident surveillance, [28] proposed a data analytics algorithm to predict and reduce the impact of traffic accidents and uncover important patterns. Relevant data for analysis were received by the Office of the Traffic Commissioner at Bangalore and included the type of accident, light condition, severity, speed zone, and alcohol consumption. 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Finally, concerning food quality surveillance, [37] presented a low-cost cooperative monitoring application based on an electronic nose tool to be used in farms to allow, in real-time, for the monitoring of gas concentrations in raw milk. Technologies 2019, 7, 58 6 of 16 3.1.2. Active Ageing Ten articles reported studies with the aim to promote the active ageing of older adults. These articles focused on different aspects that might be useful for older adults: community platforms [38–42] and applications to support daily activities [18,43–46]. The aim of [38] was to expand the current visions of smart cities for older adults by developing a web-based community platform to offer three types of services related to mutual help, local events, and local businesses. In turn, [39] focused on the development of a prototype of a platform for mobile devices that allowed the collaborative creation of walking routes based on georeferenced points of interest. Moreover, three articles, [40–42] (although [41] and [42] are part of the same project, the City4Age project), highlighted the importance of integrating the social resources of individuals into the core of what a smart city was by proposing a platform composed of various services and applications to integrate the social resources of older adult communities. Concerning the support of the activities of older adults, the retrieved articles focused on various aspects: [43,44] sought to track the location of older adults while performing outside activities; [45] also sought to track the location of older adults while developing outside activities, together with the aim to create sensor-enabled homes and surrounding spaces to support ageing in place; [18] presented the use of activity recognition, fall detection, and health monitoring features for the implementation of intelligent ambient assisted living gardens (i.e., raising awareness that gardening is a leisure activity that should be supported through IT, as it is popular in older adults); and [46] highlighted the potential of technology in public urban spaces as well as unmet challenges (e.g., to determine how to design human computer interaction for walk-up-and-use in public spaces). 3.1.3. Healthy Lifestyles Three articles were related to the promotion of healthy lifestyles, namely, physical activity for the general population [19,20,47] and two articles reporting the same project, [48,49], also aimed to promote physical activity, but for older adults, and therefore were also related to active ageing. Article [19] proposed a context-aware recommender application that offered personalized recommendations of exercise routes to individuals according to their medical conditions and real-time information from a smart city such as air quality, ultraviolet radiation, wind speed, temperature, and precipitation. The application had predefined routes and recommended the best route to individuals based on a memory-based method that employed a neighborhood search to determine groups of similar individuals. This method was validated by comparing the simulation data from two cities and virtual users where the age distribution and medical statistics (according to the reports from the World Health Organization and World Heart Federation) were compared with a real trial with 20 individuals. One article, [20], focused on the Japanese smart city of Kashiwanoha as a real-world case study. Three main approaches were applied: experiments in monitoring and visualization supported by technologies such as wearable sensors to capture continuous lifestyle data (e.g., physical activity) or forums to allow the individuals to receive feedback and advice from municipality health professionals like nurses or dietitians; educational initiatives concentrated on walking, diet, or socializing; and gamification based on the data acquired from the individuals (as gamification did not prove enough, a later financial incentive was assigned to the best performers). Although the facility was for all ages, it also impacts on active ageing since about two-thirds of the regulars were over 60 years old. The study in [47] introduced the concept of "persuasive cities" by presenting an ecosystem for the future of cities. Supported in behavioral change through gamification, and considering the possible definition of behavior changes, the study provides tools for the social engineering of persuasive cities. Although the strategy does not imply that a smart city must be applied, from the discussion and from the examples, it is inferred that a smart city is a key enabler of such an approach in a city context. Finally, [48,49] proposed a platform to promote physical activity for older adults through the suggestion of routes/paths intended to meet the individuals' requirements in terms of physical activity, personal preferences, and health conditions without disrupting their routines. The choice of paths Technologies 2019, 7, 58 7 of 16 was made by health professionals by taking into account the individuals' health history to determine which level of activity was adequate and what kind of exercises should be recommended. 3.1.4. Support to Disabled People Two articles reported on specific smart city applications to support disabled people [21,50]. Both articles were related to pedestrian transportation accessibility and considered individuals with or without disabilities [21] and blind individuals [50]. The work presented by [21] was based on a computational method for identifying accessibility issues in the geographical context of a city, which consisted of a distributed smart sensing architecture supported by cloud computing. In turn, [50] presented the development of an intelligent semaphore, assembled with video cameras providing image data to a computer vision system, WiFi signals, Bluetooth devices, and a global positioning system (GPS), to guide blind individuals when crossing a road on the crosswalk. 3.1.5. Response to Emergencies The 10 articles related to the response to emergencies focused on determining emergency situations [51], autonomous vehicles [22], intelligent management of emergency vehicles [23,52,53], and emergency management applications [24,54–57]. Article [51] proposed an architecture integrating vehicular ad hoc networks and sensors, which was the basis for the development of a proof of concept prototype aiming to improve the response time of emergency aid to drivers with heart attack and prevent possible resulting vehicle collisions (e.g., by detecting the cardiac arrest of drivers through voice and gesture control). In turn, [22] reported on the development of an ambulance robot equipped with an automated external defibrillator (AED) with various modes of operation from manual to autonomous function to support sudden events of cardiac arrest. During emergency situations, one important concern is the dispatch of emergency vehicles. In this context, three of the included articles were related to an intelligent traffic management application to optimize the utilization of emergency vehicles: [23] presented a multi-agent system to support rescue operations by integrating the allocation of emergency vehicles to the locations of the wounded, the way finding of emergency vehicles, and the facilities of a smart city; [52] reported on an algorithm that primarily focused on dynamically determining the green light duration, but that was also able to handle the management of emergency vehicles; and [53] considered the London Ambulance Service as a case study to introduce an enhanced routing and dispatch method that combined the concurrent assignment and redeployment of units. In terms of emergency management applications, [54] reported on the use of semantic tools to develop a framework supporting the automatic creation of conceptual models allowing the creative design of emergency management scenarios, and [55] presented the architecture of a platform with location tracking solutions that was able to capture the live location of emergency services (e.g., ambulances, police, and firefighters) in order to ensure the minimum response time to those in need. Still in terms of emergency management applications, three articles [24,56,57] proposed architectures that aimed to provide improved information infrastructure to assist emergency personnel in responding effectively and proportionally to large-scale, distributed, unstructured natural (e.g., major weather events) and man-made hazards (e.g., multi-vehicle accidents, large fires, or terrorist attacks): [24] suggested a hybrid cloud to manage wireless communication that involved a large number of heterogeneous mobile smart sensing devices; [56] proposed an infrastructure able to crowd source the multitude of human and physical sensing resources that could generate data about incidents (e.g., smartphones or vehicles) in order to build a comprehensive understanding of emergency situations and provide situational awareness and recommendations to the teams on the scene; and [57] made use of cloud, hybrid positioning, tracking, and motion detection to design the architecture of an emergency Technologies 2019, 7, 58 8 of 16 response application whereby critical contextual data from the emergency site are made available, which might help to plan effective first response strategies. 3.1.6. Care Services Organization Considering care services organization, two articles were retrieved: [58] presented an ensemble learning method that allowed for the prediction of needs in home care services, namely, when those needs largely increase, which was validated with the data available for the 27,775 citizens living in Copenhagen and receiving home care from 2013 to 2017; and [59] developed a theoretical model directed at designing value-infused citizen-focused services in smart cities. The basic argument is that, in the context of smart cities, there is a need to move from traditional broad policy making to citizen-oriented services by leveraging the capabilities of different government bodies and agencies. 3.1.7. Socialization Considering the incongruity between the virtual and the real felt by individuals while using social media services, which might cause the lack of interest from individuals in communicating with their local community at shared places, [60] proposed a platform meant to provide individuals with the conditions to share their thoughts and emotions and ensure socialization. 3.2. Technologies Being Used Since the objective of smart city technological platforms is to promote automated and intelligent processes based on the analysis of vast quantities of data, the data gathering is an important issue. Data acquired from the smart city infrastructure (e.g., air quality, pollution, noise, light conditions, ultraviolet radiation, wind speed, temperature, precipitation, sunlight propagation, electromagnetic radiation in certain area, or traffic conditions) are complemented with data provided by sensors inside vehicles, video cameras, gas sensors (e.g., gas sensors to support an electronic nose to assess milk quality [37]), and sensors or gadgets to provide continuous lifestyle monitoring that are gradually being pushed into the market, enabling more personalized services for individuals (Table 1). Furthermore, the data being processed also include data collected by online questionnaires (e.g., an online questionnaire applied to individuals using a smartphone application) or geo-tagged social media data (Table 1). Additionally, several articles reported on the use of data analytic tools to process the collected data [19,23,29,31,52–54,56–59]: recommendations of the best routers to individuals [19]; support of rescue operations by integrating smart city facilities for a better allocation of emergency vehicles to the wounded locations [23]; genome-wide association studies to better understand the link between genetic traits and disease [29]; a structured approach to collect and re-use sensor fitness data [31]; dynamically determining the duration of the green lights to better handle the management of emergency vehicles [52]; an enhanced routing and dispatch method that combines the concurrent assignment and redeployment of emergency vehicles [53]; semantic tools supporting the automatic creation of conceptual models for the creative design of emergency management scenarios [54]; crowd sourcing of the multitude of human and physical sensing resources that can generate data regarding incidents [56]; planning response to emergencies [57]; the prediction of needs in home care services [58]; and the design of value-infused citizen-focused services in smart cities [59]. Technologies 2019, 7, 58 9 of 16 Table 1. Types of data being collected. Types of Data References Data from smart city infrastructure [16,19,25,29–31,48,49,52] Data provided by sensors inside vehicles [28,51] Data provided by video cameras [50,56] Data provided by gas sensors [37] Geo-tagged social media data [34–36,56] Data collected by online questionnaire [17,33] Data provided by lifestyle monitoring devices: Location [16,21,30,31,39,40,43,45,48–50,55] Activity [18,20,24,31,41,42,48,49] Motion [24] Steps [20,48,49] Cycling cadence [31] Swim distance [31] Weight, body mass index, and body fat percentage [20] Heart rate and heart rate variability [18,31,32,44] Level of glucose [44] Temperature of the body [44] Electroencephalogram [33] Galvanic skin response [32,33] Social interactions [46] Crowd behaviors [47] Finally, two articles reported on the use of social media [38,60] and one article, [22], reported on the development of an ambulance robot equipped with an AED. Using multiple sensors for navigation (vision and range sensors) this robot might be able to navigate from a point to a given destination without losing the correct path or hitting obstacles [22]. 3.3. Maturity Level In terms of maturity level, different development stages were identified (Figure 4): eight articles proposed concepts for further development [18,25,29,32,36,40,46,50]; two articles [32,41] related to the same project reported on the ongoing activities to elicit the requirements using an interactive design approach (i.e., 35 care receivers were actively involved in all phases of the project to validate the data detection and intervention services); eight articles proposed theoretical models and applied simulation techniques to validate them [19,23,35,44,52,53,58,59] (in some cases, real data were used such as from the London Ambulance Service [53] or data available for the 27,775 citizens living in Copenhagen [58]); eight articles defined architectures [24,27,31,40,48,49,55,56], and some of them were validated (e.g., some of the components of the architecture were implemented for its validation [24] or a simulation of a use case was performed for the conceptual validation of the architecture [56]); 14 articles presented prototypes that were developed to demonstrate the feasibility of the concepts [16,17,21,22,28,30,33,34,37,47,51,54,57,60]; and four articles reported on prototypes that were assessed by real users [20,38,43,45]. Technologies 2019, 7, 58 10 of 16 Technologies 2019, 7, x FOR PEER REVIEW 9 of 15 Motion [24] Steps [20,48,49] Cycling cadence [31] Swim distance [31] Weight, body mass index, and body fat percentage [20] Heart rate and heart rate variability [18,31,32,44] Level of glucose [44] Temperature of the body [44] Electroencephalogram [33] Galvanic skin response [32,33] Social interactions [46] Crowd behaviors [47] Finally, two articles reported on the use of social media [38,60] and one article, [22], reported on the development of an ambulance robot equipped with an AED. Using multiple sensors for navigation (vision and range sensors) this robot might be able to navigate from a point to a given destination without losing the correct path or hitting obstacles [22]. 3.3. 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Figure 4. Maturity of the solutions assuming the goal is its deployment in a city. 4. Discussion Regarding the first research question (i.e., the most relevant application domains), three domains of application emerged as the most important: population surveillance (14 articles), response to emergencies (10 articles), and active ageing (10 articles). Moreover, four additional application Figure 4. Maturity of the solutions assuming the goal is its deployment in a city. 4. Discussion Regarding the first research question (i.e., the most relevant application domains), three domains of application emerged as the most important: population surveillance (14 articles), response to emergencies (10 articles), and active ageing (10 articles). Moreover, four additional application domains were identified: the promotion of a healthy lifestyle (five articles), support to disabled people (two articles), care services organization (two articles), and socialization (one article). These results show that smart cities can have an impact on public health (i.e., disease prevention and health promotions), which is in line with some of the current concerns. Monitoring and surveillance form an important part of the international health inequities agenda [61,62]. There is a range of routine data acquisition such as disease surveillance, healthcare utilization registries, health services statistics, or administrative records, which provide information for monitoring the health status and health outcomes of the population, but these records only provide information on individuals who seek healthcare [61]. Therefore, the implementation of smart cities represents an opportunity to seek innovative ways to gather data from all individuals. Concerning the response to emergencies, the infrastructure of smart cities allows for distributed monitoring and remote-control facilities, which might be the basis for effective responses, even under critical uncertainty conditions. The availability of incident control and crisis management intelligence by collecting, integrating, and processing all the possible data might be one of the most interesting and useful smart city services [24]. Active aging can be understood as a process of optimizing opportunities for social participation, maintaining health conditions, and for the safety of the individuals to promote their quality of life as they age [63–65]. Since active ageing must consider not only the characteristics of older adults, but also the environmental factors that can act as barriers or facilitators [65], well-designed technological solutions can act as facilitators. Since physical activity impacts on health conditions and current recommendations advise individuals to regularly perform it, there is an extensive body of research on technological solutions to promote physical activity interventions. In this respect, the promotion of healthy lifestyles should be considered when implementing human friendly cities. Regarding the last application domains (support to disabled people, organization of care services, and socialization), they are of paramount importance in modern societies. As a result of societal advances, namely those resulting from scientific and technological developments or from the pressure of civil rights movements to integrate disabled people into mainstream society, it has become generally accepted that eliminating the barriers that affect the performance of disabled people is important [66]; that new forms of organizing social services are needed to ensure the sustainability of health and Technologies 2019, 7, 58 11 of 16 social care systems [67]; and loneliness and social exclusion are generally understood to have dramatic consequences [68]. In terms of the technologies being used (i.e., the second research question), together with data acquired from the smart city infrastructure, social media, and online questionnaires, a wide range of sensors have been used to record individuals' data (e.g., location, activity or physiological parameters) (Table 1). Moreover, several algorithms have been proposed to process these data and one article, [22], reported on the development of an autonomous robot that acted as an ambulance equipped with an AED. Finally, regarding the third research question (i.e., the maturity level of the applications being reported), smart cities are emerging as rather complex endeavors because their implementation is difficult to shape and coordinate since they require the cooperation of different stakeholders (e.g., public and private sectors, citizens, or domain experts) and complex distributed applications supporting vast amount of data. As a consequence of this complexity, there is the need to re-think research methods, design processes, and assessment frameworks to meet the specific challenges of this new domain. Therefore, smart cities are complex eco-systems that require new theoretical and multidisciplinary approaches. In this respect, surprisingly, the retrieved articles did not propose new methodological developments and assessment approaches. Only four articles reported on prototypes that were assessed with real users [20,38,43,45]. The remaining articles reported on concepts for further development, the elicitation of the requirements, theoretical models that were validated using simulation techniques, definition of architectures, definition and validation of architectures, and prototypes to demonstrate the feasibility of the concepts (Figure 4). Considering the assessment of the prototypes, [38] reported on the development of a web-based community platform to offer social media services related with mutual help, local events, or local businesses. Over 100 active and independent individuals (aged 60–81) were involved in two case studies of age-friendly smart communities, which ranged from designing a mutual help service to co-creating routes of geo-located information on different topics. In turn, an intelligent application with personalized multimedia content was used to locate individuals, and was tested in a small locality in the province of Salamanca, Spain, with the tracking system activated in four homes [43]. Moreover, the application reported by [45] aimed to create sensor-enabled homes in support of ageing in place and the first demonstration was performed in an elderly home care in Singapore using wireless sensor networks integrated with a healthcare services platform. At the time of publishing the article, data was still being gathered, so no conclusions were drawn by the authors. Finally, in [20], the method of obtaining evidence that supported the results was through qualitative data obtained from primary and secondary data sources: primary data were collected between 2014 and 2017 through four on-site visits and interviews with eight individuals were selected to provide a range of perspectives and experiences on health initiatives in Kashiwanoha; and the secondary data were derived from a documentary study of newspapers and magazines, promotional and explanatory materials of smart cities, internal project documents, and academic publications. The study found that individuals were well engaged and were observed to have made concrete changes toward healthier lifestyles in their behavior. However, according to the authors, a limitation of the study is its portability to other cities: data-driven approaches to health management risk bumping against social norms as in other cultures, both individuals and municipalities are not prepared to share individual information. Moreover, the case study suggests a new approach to smart urban development. Digital technologies are framed not as an end in themselves, but as tools for dealing with social issues and improving the livelihoods of individuals [20]. Most of the retrieved articles generally tended to describe technological solutions. Within the topic under study, there are several articles that underlined the importance of going beyond technological determinism and, accordingly, considering the individuals' perspectives, with the exception of the Technologies 2019, 7, 58 12 of 16 study reported by [20], all the remaining articles reported on solutions still far from consolidated solutions. Therefore, in terms of the major barriers for the dissemination of the applications being reported (i.e., the fourth research question), a major drawback is the lack of robust evidence to facilitate the dissemination process. Although technologies should respond to the individuals' needs and not the other way around, within this set of included articles, there seems to be scarce concern in verifying the effectiveness of the solutions designed to fit the individuals' perspectives. This was emphasized by the lack of assessment of the solutions being used by individuals.

3. System Analysis

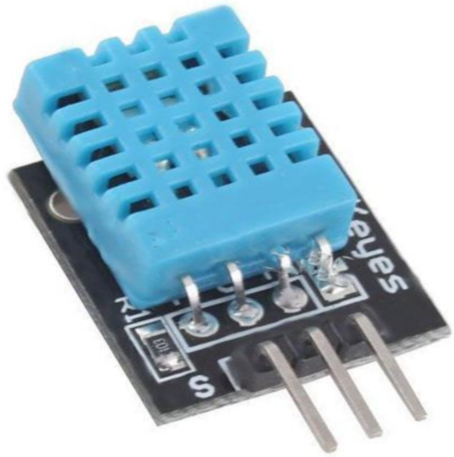
3.1 Existing System

- Overall work related to development of Prediction and Recommendation system for Covid-19 using raspberry pi which consist of microcomputer equipped with various sensors like Heart beat sensor, ECG sensor, body Temperature sensor, blood pressure sensor which is connected directly to internet through on-board Wi-Fi and health related monitoring can be done. At present, no portable healthcare system is available.
- The main disadvantage to design health monitoring system is large size.
- For designing of Health care monitoring system using Intel Galileo and database stored on local server using XAMPP server gives higher delay with larger hardware required. So, as to reduce the delay and to minimize the power consumption we can use node mcu with database stored on internet.
- Hence, designing of IOT based health monitoring system using node mcu with high speed and less area will be the probable outcome of this proposed work.
- In existing there is not any kind of data evaluation done. So that it is necessary to develop a system which will work with more and highly efficient data manipulation technique.

3.2 Hardware and software requirements

Hardware requirements

1. DHT11



Pin Identification and Configuration:

No:	Pin Name	Description
For DHT11 Sensor		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	NC	No Connection and hence not used
4	Ground	Connected to the ground of the circuit

For DHT11 Sensor module		
1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	Ground	Connected to the ground of the circuit

DHT11 Specifications:

- Operating Voltage: 3.5V to 5.5V
- Operating current: 0.3mA (measuring) 60uA (standby)
- Output: Serial data
- Temperature Range: 0°C to 50°C
- Humidity Range: 20% to 90%
- Resolution: Temperature and Humidity both are 16-bit
- Accuracy: ±1°C and ±1%

The **DHT11** is a commonly used **Temperature and humidity sensor.** The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%. So if you are looking to measure in this range then this sensor might be the right choice for you.

2. Pulse Oximeter

The sensor is integrated **pulse oximetry** and **heart-rate monitor** sensor solution. It combines two **LED's, a photodetector, optimized optics**, and low-noise analog signal processing to detect pulse and heart-rate signals. It operates from **1.8V** and **3.3V** power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

Features of MAX30100 Pulse Oximeter

1. Consumes very low power (operates from 1.8V and 3.3V)
2. Ultra-Low Shutdown Current (0.7µA, typ)
3. Fast Data Output Capability

Working of MAX30100 Pulse Oximeter and Heart-Rate Sensor

The device has two **LEDs, one emitting red light, another emitting infrared light**. For pulse rate, only the **infrared light** is needed. Both the **red light** and **infrared light** is used to measure oxygen levels in the blood.

When the heart pumps blood, there is an increase in **oxygenated blood** as a result of having more blood. As the heart relaxes, the volume of oxygenated blood also decreases. By knowing the time between the increase and decrease of oxygenated blood, the **pulse rate** is determined.

It turns out, **oxygenated blood** absorbs more infrared light and passes more red light while **deoxygenated blood** absorbs red light and passes more infrared light. This is the main function of the **MAX30100**: it reads the absorption levels for both light sources and stored them in a buffer that can be read via I2C.

3. NodeMCU

NodeMCU is an open source Lua based firmware for the ESP8266 WiFi SOC from Espressif and uses an on-module flash-based SPIFFS file system. NodeMCU is implemented in C and is layered on the Espressif NON-OS SDK.The firmware was initially developed as is a companion project to the popular ESP8266-based NodeMCU development modules, but the project is now community-supported, and the firmware can now be run on *any* ESP module. NodeMCU is an open source firmware for which open source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit).[8] The term "NodeMCU" strictly speaking refers to the firmware rather than the associated development kits.

4. RAM of 8 GB

5. i3 processor

6. 500 GB of hard disk

Software requirements

1. Android Studio

1Android Studio is the official Integrated Development Environment (IDE) for android application development. Android Studio provides more features that enhance our productivity while building Android apps.

Android Studio was announced on 16th May 2013 at the Google I/O conference as an official IDE for Android app development. It started its early access preview from version 0.1 in May 2013. The first stable built version was released in December 2014, starts from version 1.0.

Since 7th May 2019, Kotlin is Google's preferred language for Android application development. Besides this, other programming languages are supported by Android Studio.

Features of Android Studio

- It has a flexible Gradle-based build system.
- It has a fast and feature-rich emulator for app testing.
- Android Studio has a consolidated environment where we can develop for all Android devices.
- Apply changes to the resource code of our running app without restarting the app.
- Android Studio provides extensive testing tools and frameworks.
- It supports C++ and NDK.
- It provides build-in supports for Google Cloud Platform. It makes it easy to integrate Google Cloud Messaging and App Engine.

2. JDK 8.0

The **Java Development Kit** (**JDK**) is an implementation of either one of the Java Platform, Standard Edition, Java Platform, Enterprise Edition, or Java Platform, Micro Edition platforms released by Oracle Corporation in the form of a binary product aimed at Java developers on Solaris, Linux, macOS or Windows. The JDK includes a private JVM and a few other resources to finish the development of a Java application. Since the introduction of the Java platform, it has been by far the most widely used Software Development Kit (SDK).The JDK is available for 64-bit x64 macOS (and that version also works with Rosetta 2), while an early access build (developer preview) from Microsoft is also available to support recent Apple M1 Macs.The JDK has as its primary components a collection of programming tools, including:

- appletviewer – this tool can be used to run and debug Java applets without a web browser
- apt – the annotation-processing tool[6]
- extcheck – a utility that detects JAR file conflicts
- idlj – the IDL-to-Java compiler. This utility generates Java bindings from a given Java IDL file.
- jabswitch – the Java Access Bridge. Exposes assistive technologies on Microsoft Windows systems.
- java – the loader for Java applications. This tool is an interpreter and can interpret the class files generated by the javac compiler. Now a single launcher is used for both development and deployment. The old deployment launcher, jre, no longer comes with Sun JDK, and instead it has been replaced by this new java loader.
- javac – the Java compiler, which converts source code into Java bytecode
- javadoc – the documentation generator, which automatically generates documentation from source code comments
- jar – the archiver, which packages related class libraries into a single JAR file. This tool also helps manage JAR files.
- javafxpackager – tool to package and sign JavaFX applications
- jarsigner – the jar signing and verification tool
- javah – the C header and stub generator, used to write native methods
- javap – the class file disassembler
- javaws – the Java Web Start launcher for JNLP applications
- JConsole – Java Monitoring and Management Console
- jdb – the debugger
- jhat – Java Heap Analysis Tool (experimental)
- jinfo – This utility gets configuration information from a running Java process or crash dump. (experimental)
- jmap Oracle jmap - Memory Map– This utility outputs the memory map for Java and can print shared object memory maps or heap memory details of a given process or core dump. (experimental)

- jmc – Java Mission Control
- jpackage – a tool for generating self-contained application bundles. (experimental)
- jps – Java Virtual Machine Process Status Tool lists the instrumented HotSpot Java Virtual Machines (JVMs) on the target system. (experimental)
- jrunscript – Java command-line script shell.
- jshell - The new jshell introduced in java 9.
- jstack – utility that prints Java stack traces of Java threads (experimental)
- jstat – Java Virtual Machine statistics monitoring tool (experimental)
- jstatd – jstat daemon (experimental)
- keytool – tool for manipulating the keystore
- pack200 – JAR compression tool
- policytool – the policy creation and management tool, which can determine policy for a Java runtime, specifying which permissions are available for code from various sources.
- VisualVM – visual tool integrating several command-line JDK tools and lightweight[clarification needed] performance and memory profiling capabilities
- wsimport – generates portable JAX-WS artifacts for invoking a web service.
- xjc – Part of the Java API for XML Binding (JAXB) API. It accepts an XML schema and generates Java classes.

Advantages

- Proposed system will help to monitor the patients from anywhere anytime
- Intelligence system will help to monitor the complete health of the patient using single device
- Doctors can able to control and maintain the track of every patient on single click
- Serious patient can be identified easily and send the alert easily
- Help to track to track the patient in corona pandemic

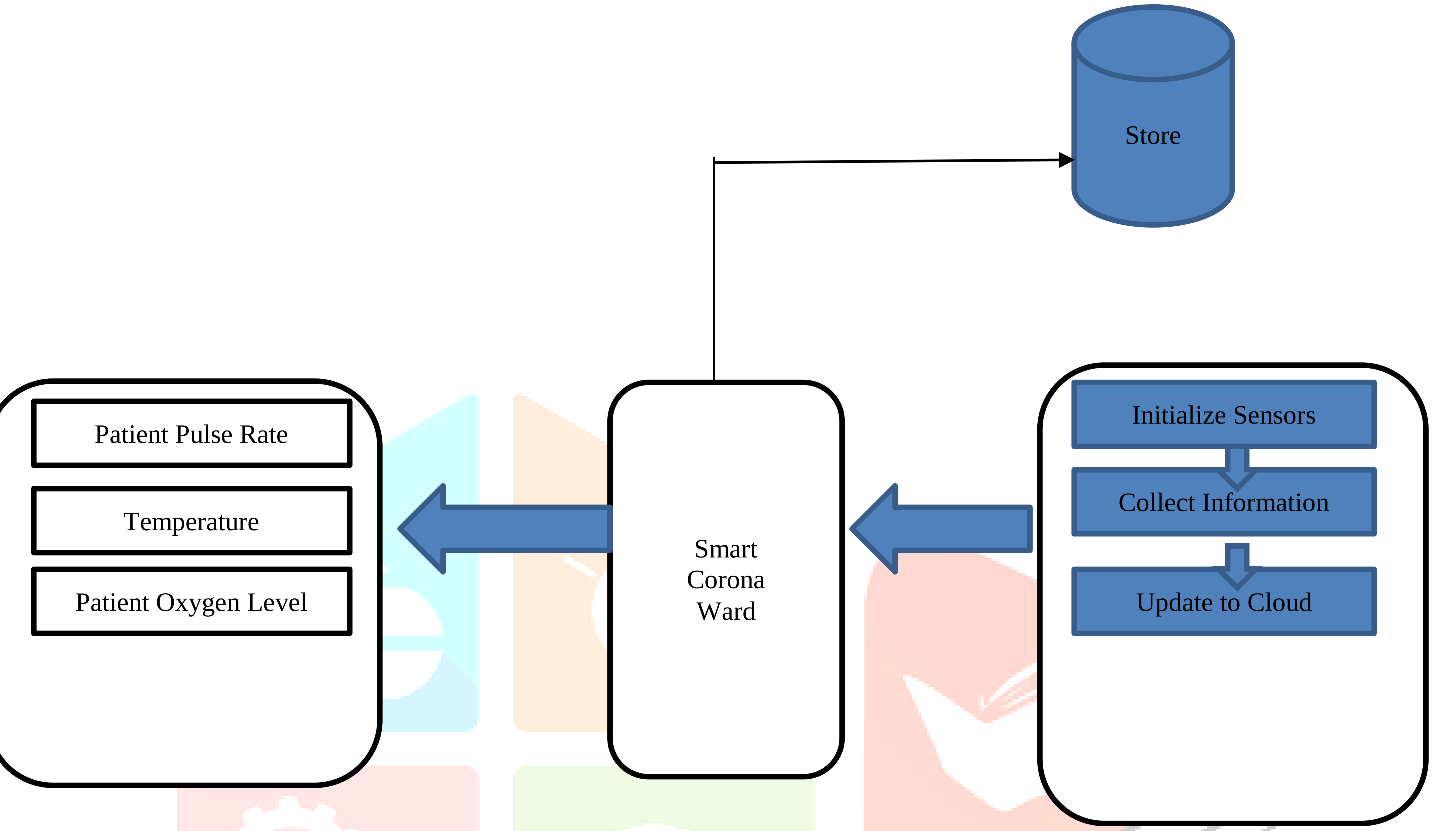
Disadvantages

- The proposed system always needs internet connectivity if the connectivity loss, then system will be unable to send the data

4. System Design

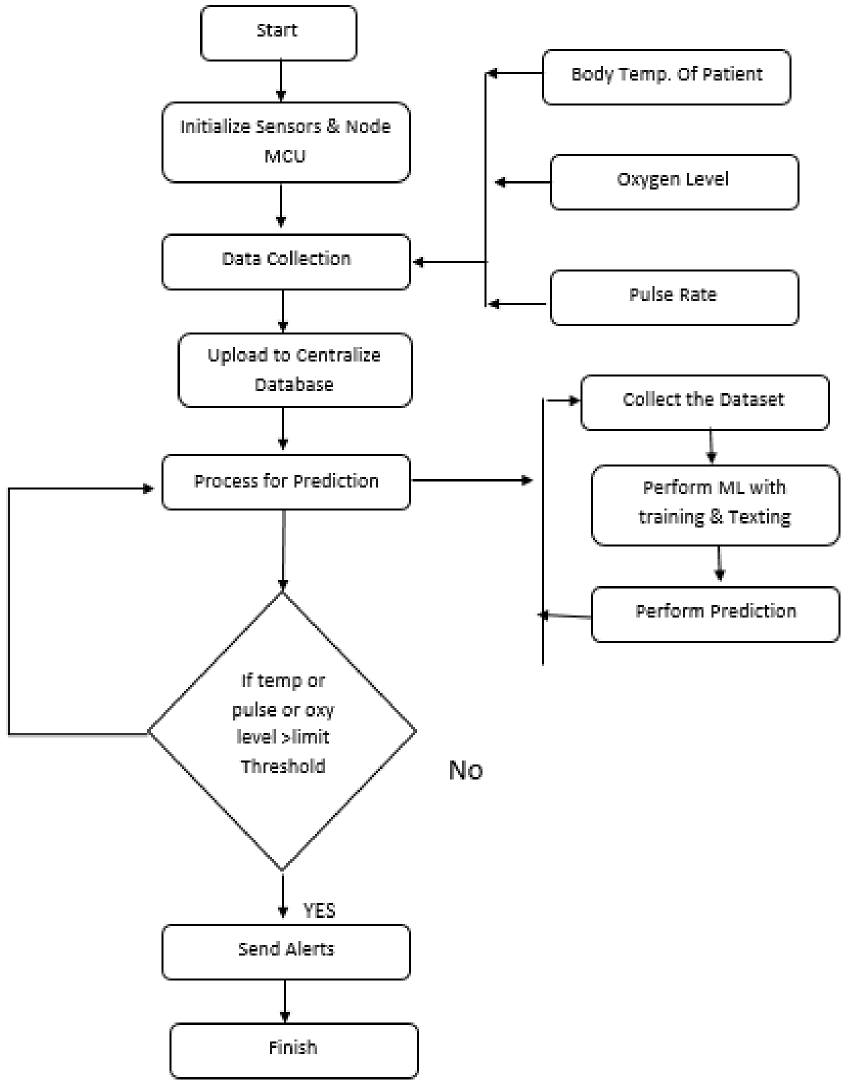
4.1 Proposed system architecture

Block diagram



4.2 Proposed system design

Flowchart



4.3 Proposed Algorithm

Apriori algorithm is given by R. Agrawal and R. Srikant in 1994 for finding frequent itemsets in a dataset for Boolean association rule. Name of the algorithm is Apriori because it uses prior knowledge of frequent itemset properties. We apply an iterative approach or level-wise search where k-frequent itemsets are used to find k+1 itemsets.

To improve the efficiency of level-wise generation of frequent itemsets, an important property is used called *Apriori property* which helps by reducing the search space.

Apriori Property –

All non-empty subset of frequent itemset must be frequent. The key concept of Apriori algorithm is its anti-monotonicity of support measure.

TID	items
T1	I1, I2 , I5
T2	I2,I4
T3	I2,I3
T4	I1,I2,I4
T5	I1,I3
T6	I2,I3
T7	I1,I3
T8	I1,I2,I3,I5
T9	I1,I2,I3

minimum support count is 2
minimum confidence is 60%

Step-1: K=1

(I) Create a table containing support count of each item present in dataset – Called **C1(candidate set)**

Itemset	sup_count
I1	6
I2	7
I3	6
I4	2
I5	2

(II) compare candidate set item's support count with minimum support count(here min_support=2 if support_count of candidate set items is less than min_support then remove those items). This gives us itemset L1.

Itemset	sup_count
I1	6
I2	7
I3	6
I4	2
I5	2

Step-2: K=2

- Generate candidate set C2 using L1 (this is called join step). Condition of joining L_{k-1} and L_{k-1} is that it should have (K-2) elements in common.
- Check all subsets of an itemset are frequent or not and if not frequent remove that itemset. (Example subset of {I1, I2} are {I1}, {I2} they are frequently checked for each itemset)
- Now find support count of these item sets by searching in dataset.

Itemset	sup_count
I1,I2	4
I1,I3	4
I1,I4	1
I1,I5	2
I2,I3	4
I2,I4	2
I2,I5	2
I3,I4	0
I3,I5	1
I4,I5	0

(II) compare candidate (C2) support count with minimum support count(here min_support=2 if support_count of candidate set item is less than min_support then remove those items) this gives us itemset L2.

Itemset	sup_count
I1,I2	4
I1,I3	4
I1,I5	2
I2,I3	4
I2,I4	2
I2,I5	2
I2,I5	2

Step-3:

- Generate candidate set C3 using L2 (join step). Condition of joining L_{k-1} and L_{k-1} is that it should have (K-2) elements in common. So here, for L2, first element should match. So itemset generated by joining L2 is {I1, I2, I3}{I1, I2, I5}{I1, I3, i5}{I2, I3, I4}{I2, I4, I5}{I2, I3, I5}
- Check if all subsets of these itemsets are frequent or not and if not, then remove that itemset.(Here subset of {I1, I2, I3} are {I1, I2},{I2, I3},{I1, I3} which are frequent. For {I2, I3, I4}, subset {I3, I4} is not frequent so remove it. Similarly check for every itemset)
- find support count of these remaining itemset by searching in dataset.

Itemset	sup_count
I1,I2,I3	2
I1,I2,I5	2

(II) Compare candidate (C3) support count with minimum support count(here min_support=2 if support_count of candidate set item is less than min_support then remove those items) this gives us itemset L3.

Itemset	sup_count
I1,I2,I3	2
I1,I2,I5	2

Step-4:

- Generate candidate set C4 using L3 (join step). Condition of joining L_{k-1} and L_{k-1} (K=4) is that, they should have (K-2) elements in common. So here, for L3, first 2 elements (items) should match.

- Check all subsets of these itemsets are frequent or not (Here itemset formed by joining L3 is {I1, I2, I3, I5} so its subset contains {I1, I3, I5}, which is not frequent). So no itemset in C4
- We stop here because no frequent itemsets are found further

Thus, we have discovered all the frequent item-sets. Now generation of strong association rule comes into picture. For that we need to calculate confidence of each rule.

Confidence –
A confidence of 60% means that 60% of the customers, who purchased milk and bread also bought butter.

Confidence(A->B)=Support_count(A∪B)/Support_count(A)

So here, by taking an example of any frequent itemset, we will show the rule generation.
Itemset {I1, I2, I3} //from L3
SO rules can be
[I1^I2]=>[I3] //confidence = sup(I1^I2^I3)/sup(I1^I2) = 2/4*100=50%
[I1^I3]=>[I2] //confidence = sup(I1^I2^I3)/sup(I1^I3) = 2/4*100=50%
[I2^I3]=>[I1] //confidence = sup(I1^I2^I3)/sup(I2^I3) = 2/4*100=50%
[I1]=>[I2^I3] //confidence = sup(I1^I2^I3)/sup(I1) = 2/6*100=33%
[I2]=>[I1^I3] //confidence = sup(I1^I2^I3)/sup(I2) = 2/7*100=28%
[I3]=>[I1^I2] //confidence = sup(I1^I2^I3)/sup(I3) = 2/6*100=33%

So if minimum confidence is 50%, then first 3 rules can be considered as strong association rules.

5. Conclusion

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