
MONITORING HEALTH: SENSORS IN SMARTPHONES

Dr. M K Jayanti Kannan

Faculty of Engineering and Technology, Jain (Deemed-to-be University), Ramnagar District, Karnataka – 562112

Email Id- k.jayanthi@jainuniversity.ac.in

Abstract:

Over the last two decades, thanks to major developments in medical science and technology, medication, and extensive understanding of diet, education, and personal and environmental health, we have seen a substantial rise in lifespan. Additionally, the elderly population is projected to grow steadily in the future years in many parts. In terms of costs correlated with their health care and well-being, an increasingly growing ageing population is projected to adversely impact the socio-economic structures of many nations. Furthermore, illnesses linked to the digestive system, the eye, immune system, skin and mental wellbeing are internationally common. However, by constant observation, most of these diseases can be prevented and/or adequately handled. Affordable, non-invasive and easy-to-use healthcare technologies are essential in order to allow ongoing patient surveillance and to satisfy rising healthcare needs. Combined with embedded sensors and new communication technologies, the ever-increasing penetration of smartphones makes it an appealing technology to allow continuous and remote tracking of the safety and well-being of a person with minimal extra costs. In this article, we present a thorough overview of state-of-the-art studies and advancements in healthcare technology focused on mobile sensors. A debate on regulatory strategies for medical devices and their consequences in smartphone-based healthcare systems is discussed. Finally, it addresses certain potential research insights and questions around smartphone-based healthcare services.

Keywords: *Hearing Impairment, Health, Mental, Monitoring, Skin, Sleep, Smartphones.*

I. INTRODUCTION

Existence expectancy in many countries has expanded notably over the past several many years. This massive increase may be attributed ordinarily to the extraordinary advances in healthcare and clinical technology, and the developing focus approximately health, nutrients, sanitation, and training. But, this extended life expectancy, blended with the globally reducing birth rate is anticipated to result in a large aging populace within the near destiny. In reality, the elderly populace over the age trendy 65 years is anticipated to outnumber the youngsters beneath the age trendy 14 years by way of 2050. Moreover, about 15% trendy the arena's population have a few state-of-the-art disability, and a hundred and ten–one hundred ninety million adults be afflicted by important functional difficulties. Disability brand new

any form in a person limits mobility and independence, consequently preventing or delaying them from receiving important healthcare guide on time.

Further, a full-size wide variety brand new human beings around the globe be afflicted by persistent diseases and scientific situations inclusive of cardiovascular diseases, lung diseases, one-of-a-kind ultra-modern cancer, diabetes and diabetes-associated complications. It's far said that six present day ten American adults (>18 years) suffer from at the least one continual sickness, with 4 today's ten having multiple persistent situations. Similarly, continual sicknesses account for~65–70% ultra-modern total mortality a few of the ten main causes ultra-modern loss of life. In fact, heart sickness and cancer together account for forty eight% brand new all deaths, accordingly becoming the leading cause contemporary mortality. Further, the unregulated blood sugar i.e. Diabetes is in all likelihood to be the seventh leading cause present day demise by using 2030. Diabetes will increase the danger state-of-the-art long-time period headaches such as kidney failure, limb amputations, and diabetic retinopathy (DR). Diabetic retinopathy is an eye fixed disorder that consequences from the harm brand new retinal blood vessels today's the prolonged presence ultra-modern excessive glucose inside the blood. It can result in blindness if no longer handled in time. In reality, DR turned into anticipated to account for five million blindness globally in 2002. Other generic eye-associated sicknesses include cataract, glaucoma, and age-related macular degeneration (AMD) that together with DR caused 65% modern-day all blindness globally in 2010, with cataract by myself accounting for 51%. Moreover, negative air great in lots of large cities threatens city-dwellers with diseases like allergies and lung sicknesses. Globally, an envisioned 235 million people are presently stricken by bronchial asthma, which brought about 383,000 deaths in 2015. Therefore, the call for for healthcare services is understandably rising extra hastily than ever before [1].

The vast advances in power efficient and high-pace computing and communication technologies have revolutionized the worldwide telecom industry. Moreover, the enormous progress in display, sensor and battery technology together have paved the way for cutting-edge cell gadgets including smartphones and drugs, allowing seamless internet connectivity, amusement, and health and fitness monitoring on the go with traditional voice and text communication. Smartphones have grown in reputation over the past decade and by means of 2021, the worldwide penetration brand new smartphones is expected to exceed 3.8 billion. Present day smartphones include trendy embedded sensors such as a high-decision complementary metallic-oxide semiconductor (CMOS) photo sensor, international positioning machine (GPS) sensor, accelerometer, gyroscope, magnetometer, ambient light sensor and microphone. these sensors may be used to degree numerous fitness parameters inclusive of coronary heart price (HR), HR variability (HRV), respiratory fee (RR), and fitness situations such as pores and skin sicknesses and eye diseases, accordingly turning the conversation device into a continuous and long-time period health tracking machine. In this newsletter, we present an in depth evaluation state-of-the-art the current nation modern day studies and development inside the fitness tracking structures based totally-on embedded sensors in smartphones [2].

II. DISCUSSION

Smartphone Sensors for Health Monitoring

As discussed earlier, the modern-day smartphones are outfitted with cutting-edge sensors. Those sensors allow for energetic and/or passive sensing brand new several fitness

parameters and fitness situations. The statistics accordingly measured by means of the cell phone-sensors, brand new ten coupled with facts associated with tool usage including name logs, app utilization and short message carrier (SMS) patterns can offer valuable information trendy an man or woman's physical and intellectual health over a protracted period of time. On this manner, the cell phone can potentially be changed into a possible and cost-effective device for continuous health tracking. In the following sections, we talk how the smartphone may be used for heart, eye, skin, mental health and pastime tracking, respectively.

Cardiovascular Health Monitoring

Coronary heart rate (HR) or pulse rate is one of the 4 'important symptoms' that is robotically monitored by physicians to diagnose coronary heart-related illnesses together with unique cutting-edge arrhythmias. HR and HR variability (HRV) are usually extracted from the Electrocardiogram (ECG). However, those structures, especially the conventional 12-lead ECG structures are pricey, limit person's movement and require educated clinical specialists to perform in clinical settings. HR and HRV can also be measured the usage of transportable and single-lead ECG gadgets. Moreover, with the development cutting-edge wearable sensor technology, HR and HRV can now be acquired using business health trackers along with Fitbit (San Francisco, CA, USA), Jawbone (San Francisco, CA, United States), Striiv (Redwood metropolis, CA, US), and Garmin, (Olathe, KS, USA). Pulmonary health monitoring Air pollution throughout the globe has improved appreciably within the last decade ensuing in billions trendy people being at expanded danger for persistent pulmonary sicknesses together with cough, allergies, chronic obstructive pulmonary disorder (COPD) and lung cancer. Similarly, smoking tobacco is one of the key chance elements for lung most cancers and different pulmonary illnesses. In reality, lung cancer is the most common shape modern cancers and brought on ~19% present day all most cancers-related deaths in 2018. Therefore, early detection of these lung sicknesses and non-stop tracking cutting-edge pulmonary health are paramount for well timed and powerful medical intervention. Many researchers used the microphone cutting-edge a phone to discover the sound today's a cough and respiration and analyzed the recorded audio indicators in efforts to develop a cost-effective and transportable device for faster assessment trendy pulmonary health [3].

Ophthalmic Health Monitoring

Diabetic Retinopathy (DR) is one of the not unusual complications ultra-modern diabetes, which if identified past due and left untreated, can result in blindness. Currently, the seven-discipline stereoscopic-dilated fundus pictures are considered as the 'gold preferred' for diagnosing DR through the Early remedy latest Diabetic Retinopathy examine (ETDRS) institution. However, this protocol calls for an high priced imaging device, specifically-skilled pictures employees, and specialized processing and garage modern movies. Single-field virtual fundus pictures, despite the fact that now not as complete as the seven-subject stereoscopic-dilated fundus photography, can still serve as a screening tool for DR earlier than a detailed ophthalmic assessment and control. Single-subject virtual fundus imaging is much less pricey and extra convenient in evaluation to the standard seven-discipline stereoscopic ETDRS photography.

But, this gadget continues to be steeply-priced with a rate trendy the complete imaging device ranging from numerous thousand to 10 thousand dollars, consequently restricting its large-scale adoption for diagnosing DR and different eyes-related diseases, specifically in growing and under-evolved countries. But, the ever-growing recognition and fast technological

advances cutting-edge telephone digital camera as, coupled with modern-day cloud-based photo processing, storage and management services have paved the manner for low-value and efficient remote screening and analysis brand new ophthalmic sicknesses. This smartphone-based totally imaging generation can potentially be beneficial in inpatient consultations and emergency room visits [4][5].

Skin Health Monitoring

Pores and skin cancer is one of the maximum commonplace present day all human cancers this is because of the odd increase latest pores and skin tissue. Experts have identified three fundamental present day skin most cancers basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and cancer, the malignant shape modern-day the latter being the most risky one a few of the three. Melanoma is by and large as a result of over-exposed to dangerous extremely-violet rays today's the sun that hinders melanin synthesis by way of damaging the genetic material present day the melanin-producing melanocyte cells ultra-modern the skin and for this reason putting people at excessive chance present day skin most cancers. Malignant melanoma tends to unfold to different parts state-of-the-art the frame and might turn deadly if no longer recognized and handled early. Consistent with the the united states cancer Society, 91,270 new cases brand new skin cancer have been envisioned to be diagnosed inside the US in 2018, out trendy which 9320 deaths had been predicted. Pores and skin cancer is characterized via the improvement today's precancerous lesions with varying form, length, shade and texture. Apart from pores and skin cancer, there are other today's skin illnesses along with psoriasis, eczema, and moles that require medical interest, thus causing loss of productiveness and boom in medical fees. In truth, one in four Americans underwent treatment for as a minimum one skin ailment in 2013, costing \$eleven billion in misplaced productiveness and \$75 billion for treatment and related costs. Consequently, a low-cost answer for early detection latest pores and skin sickness could be today's mammoth use. Smartphones, being extensively popular at gift, can offer a possible answer for early diagnosis modern day pores and skin illnesses, maximum particularly for far flung screening and long-term monitoring modern day pores and skin lesions [6].

Mental Health Assessment

As noted earlier, present-day smartphones have today's embedded sensors which include accelerometer, GPS, mild sensor and microphone. The data from these embedded sensors may be collected passively with the phone, which coupled with the user's cell phone utilization statistics which includes name history, SMS pattern and application usage may also doubtlessly be used to digitally phenotype an character's conduct and investigate one's intellectual health. For instance, a man or woman's strain level or emotional country can be deduced from their voice even as talking over the phone and recording the communication with the smartphone's microphone. Similarly, the accelerometer can provide facts approximately physical pastime and movement at some point of sleep. The GPS can provide statistics about the area and thus the context and variety of interest. Consequently, the telephone permits a much less intrusive and extra precise opportunity to the traditional self-reporting method, and it can be very useful in assessing the mental well-being state-of-the-art an character [7].

Activity and Sleep Monitoring Systems

Daily bodily activities inclusive of strolling, jogging and mountain climbing stairs contain numerous joints and muscle mass latest the body and require right coordination among the fearful system and the musculoskeletal machine. Consequently, any abnormalities inside the functioning of these biological systems may additionally doubtlessly have an effect on the natural styles of those sports. For example, folks on the early onset present day parkinson's sickness tend to show off small and shuffled steps, and from time to time enjoy difficulties to start, forestall and take turns while on foot. Moreover, today's slow deterioration present day motor control with age, older adults are at high risk brand new fall and mobility disability. In fact, an estimated 10% (2.7 million) ultra-modern Canadians, aged 15 years and over, suffered from mobility-related disabilities in 2017. Furthermore, falls in the older adults may also purpose hip and bone fractures, joint injuries, and demanding brain damage, which not simplest require longer recovery time but additionally restrict physical motion thereby affecting an person's every day activities. Further, fall-related fractures reportedly have a sturdy correlation with mortality. Moreover, almost one-1/3 (30%) latest Canadian adults between 18 and seventy nine years brand new age were predicted to be at intermediate or excessive danger for sleep apnoea, that is contemporary related to excessive blood strain, heart failure, diabetes, stroke, interest deficit/hyperactivity disorder, and increased car accidents. Therefore, quantitative assessment modern day gait, knee joints and every day sports which includes sleep are critical in early diagnosing musculoskeletal or cognitive diseases, sleep issues, fall and stability evaluation, in addition to within the publish-harm rehabilitation period [8].

Hearing Impairment Monitoring Systems

In line with the World health Organisation (WHO), 6.1% trendy the arena's population which include one-1/3 state-of-the-art the adults elderly sixty five or above be afflicted by unique degrees modern listening to loss. Furthermore, the range brand new humans with disabling listening to impairment is anticipated to develop swiftly over the coming years, accomplishing 630 million with the aid of 2030 and over 900 million in 2050. Listening to impairment at mild to moderate degree may additionally purpose people to lose 50%–70% state-of-the-art speech within the noisy surroundings and might degrade a person's great cutting-edge lifestyles, if not corrected. Commonly, a hearing check is completed with the aid of the natural-tone audiometry (PTA) to decide the listening to threshold ranges present day a person based on the patients' feedbacks to pure tones stimuli. Therefore, PTA is generally advocated for sufferers over five years state-of-the-art age i.e., old enough to comply with the check techniques. Further, PTA requires skilled employees, unique infrastructure and arrangements to keep the ambient noise stages low throughout the test and everyday maintenance present day the structures to make certain high precision and accuracy within the check effects. Therefore, listening to care services are luxurious and so are scarce, especially in developing and lesser-developed international locations. Fortunately, cell phone-based totally hearing tests programs can provide a low-cost and quicker alternative to traditional hearing screening procedures[9].

III. CONCLUSION

In this paper, a survey was conducted on health and interest tracking systems that exploit the embedded sensors in smartphones for measuring physiological parameters and monitoring fitness conditions. The ubiquity trendy smartphones has grown exceedingly in the past decade. Similarly, the sizeable advances in sensor technologies in terms ultra-modern size, fee, power requirements and sensitivity has enabled the combination state-of-the-art trendy

sensors into present-day smartphones. The embedded sensors in smartphones along with the image sensor, microphone, ambient mild sensor and motion sensors coupled with modern high-pace information switch technologies may assist human beings to guide an independent and lively lifestyles whilst making sure non-invasive monitoring in their fitness and bodily properly-being in a normal fashion without adding lots to their non-public charges.

Monitoring the health present day the coronary heart, eye, respiratory structures and skin, as well as the activities cutting-edge each day living (ADL) and mental conditions in a chronic style, can offer designated information about an character's overall health and wellbeing over a prolonged time frame. The telephone and its embedded sensors coupled with gift-day data and communications technologies have opened a brand new window contemporary opportunity for fee-effective faraway healthcare services. The raw medical facts as a result obtained via the cell phone sensors can be despatched over the net to a far flung healthcare facility for precise research. Furthermore, the incredible enhancements within the processing and facts garage abilities inside the current-day smartphones can also allow for faster, actual-time and onboard execution latest complicated predictive algorithms and/or artificial intelligence (AI) technology the usage of the excessive-quantity cutting-edge raw information measured by the cell phone sensors. Therefore, smartphones may also play an exquisite role in enabling a low-cost solution for early diagnosis thru non-stop monitoring, preliminary screening cutting-edge illnesses consisting of melanoma, and diabetic retinopathy and remote tracking brand new the development present day some illnesses.

IV. REFERENCES

- [1] X. Su, H. Tong, and P. Ji, "Activity recognition with smartphone sensors," *Tsinghua Sci. Technol.*, 2014, doi: 10.1109/TST.2014.6838194.
- [2] D. Zhang and Q. Liu, "Biosensors and bioelectronics on smartphone for portable biochemical detection," *Biosensors and Bioelectronics*. 2016, doi: 10.1016/j.bios.2015.08.037.
- [3] S. Majumder, T. Mondal, and M. J. Deen, "Wearable sensors for remote health monitoring," *Sensors (Switzerland)*. 2017, doi: 10.3390/s17010130.
- [4] E. C. Larson, T. Lee, S. Liu, M. Rosenfeld, and S. N. Patel, "Accurate and privacy preserving cough sensing using a low-cost microphone," 2011, doi: 10.1145/2030112.2030163.
- [5] B. C. Toy *et al.*, "Smartphone-based dilated fundus photography and near visual acuity testing as inexpensive screening tools to detect referral warranted diabetic eye disease," *Retina*, 2016, doi: 10.1097/IAE.0000000000000955.
- [6] A. Börve *et al.*, "Smartphone teledermoscopy referrals: A novel process for improved triage of skin cancer patients," *Acta Derm. Venereol.*, 2015, doi: 10.2340/00015555-1906.
- [7] F. Wahle, T. Kowatsch, E. Fleisch, M. Rufer, and S. Weidt, "Mobile sensing and support for people with depression: A pilot trial in the wild," *JMIR mHealth uHealth*, 2016, doi: 10.2196/mhealth.5960.
- [8] S. Madansingh, T. A. Thrasher, C. S. Layne, and B. C. Lee, "Smartphone based fall

-
- detection system,” 2015, doi: 10.1109/ICCAS.2015.7364941.
- [9] T. Bright and D. Pallawela, “Validated Smartphone-Based Apps for Ear and Hearing Assessments: A Review,” *JMIR Rehabil. Assist. Technol.*, 2016, doi: 10.2196/rehab.6074.