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The Progressive Review of Development of the Artificial intelligence Enabled Wearable Devices using Machine Learning for Healthcare

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Abstract:
The last few years have seen the critical effects of wearable devices as photonics / hardware on different parts of our a day life, as an example , medical aid checking and therapy, encompassing observing, delicate mechanical technology, prosthetics, adaptable showcase, correspondence, human-machine communications, etc. As per the development lately, the leading edge wearable gadgets and photonics are progressing quickly toward the amount of artificial consciousness (AI) and web of things (IoT), to accomplish a more elevated level of, comfort, association, and knowledge. Thus, this survey gives a perfect outline of the new advancement in wearable hardware, photonics, and frameworks, regarding arising materials, transducing components, primary designs, applications, and their further mix with different innovations. To start out with, advancement of gadgets for general wearable devices (hardware and photonics, etc.) is summed up for the uses of actual detecting, substance detecting, human-machine collaboration, show, correspondence, etc. Finally the paper is trying to review the available literature based on the Artificial Intelligence enabled wearable devices using Machine Learning for healthcare.

Keywords:- Artificial intelligence, energy harvesting, human-machine interface, internet of things, wearable electronics, wearable photonics

INTRODUCTION

Wearable gadgets, with incorporated motorized adaptability and microelectronic usefulness, have encountered blossoming improvement and progression in the previous few years.Associated to the conventional inflexible hardware, wearable hardware show interesting attributes in the parts of adaptable and additionally stretchable.[1]To progress from unbending gadgets to wearable hardware, three mainstream approaches have been comprehensively examined and applied, that is, lessening the thickness of inflexible layers, moving unbending squares on delicate substrates with stretchable interconnects, or utilizing naturally adaptable materials.[2][3][4]In such manner, wearable gadgets can accomplish similar functionalities all the more helpfully and along these lines improve the association experience among people and gadgets. Aside from the overall wearable hardware, wearable photonics including optical correspondence way can be a decent supplement and get additional focal points the entire

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wearable frameworks. [5][6][7]Wearable hardware, with incorporated mechanical adaptability and electronic usefulness, have encountered sprouting improvement[8] and progression in the previous few years. Compared to the customary unbending hardware, wearable gadgets show exceptional attributes in the parts of adaptable as well as stretchable, comparably patchable to skin, and conceivably implantable. [9][10]To progress from unbending hardware to wearable gadgets, three famous methodologies have been extensively explored and applied, that is, decreasing the thickness of inflexible layers, moving unbending squares on delicate substrates with stretchable interconnects,or utilizing naturally adaptable materials.in such manner, wearable hardware can accomplish similar functionalities all the more helpfully and consequently improve the communication[11], [12] experience among people and gadgets.[13] Aside from the overall wearable hardware, wearable photonics including optical correspondence way can be a decent supplement and get additional favorable circumstances the entire wearable frameworks.[14]
There are various applications of AI in healthcare to assist the medical staff as well as help the patients. The AI enabled healthcare applications can be illustrated in figure -1.

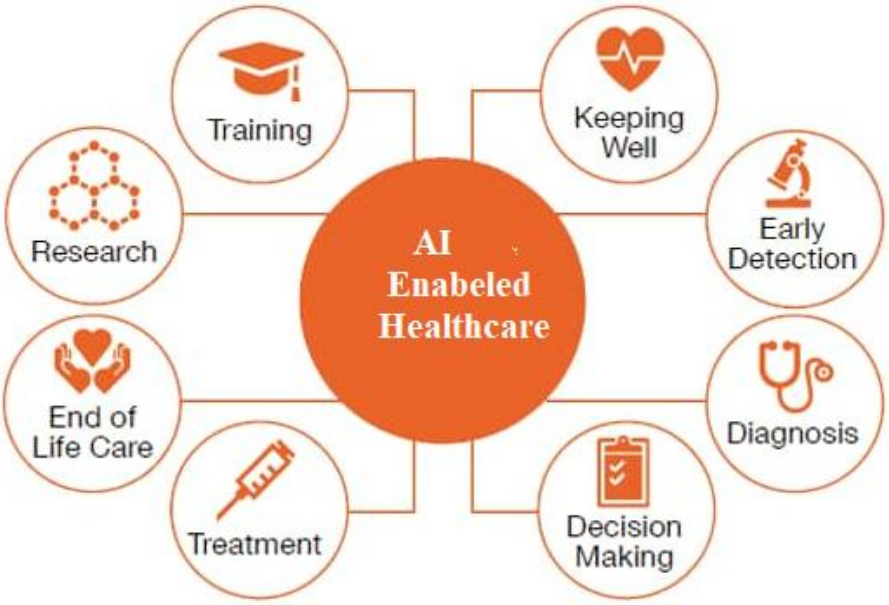

Figure -1 AI enabled healthcare applications

The following major applications of the AI based healthcare fields are as:-

- **Training: -** There are various training applications to train the health workers. There is a requirement of huge work-force in healthcare which can only be provided by the AI based training for the healthcare field.
- **Keeping Well: -**This is another application in health sector where various wearable devices are developed to measure thereal-time health parameter. It is very important for the vulnerable patients.

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- **Early Detection:** - When the various real-time health parameters are measure by the AI enable devices then various sophisticated algorithms are available to detect the disease in early stage. These prediction algorithms are generally based on machine learning, deep learning and other AI enabled technologies.
- **Diagnosis:** - Today various scans are available to diagnose the problems in human body. It is very useful to detect the actual problem so that the medical experts will cure the problem with effectively.
- **Decision Making:** - The decision making is another AI enabled application to give the optimum solution for the identified issue. For the new medical officers and practitioners are required this type of assistance to make the decision more correct and effective.
- **Treatment:** - Various AI enabled expert systems, surgery systems and other related systems are available for patients. Therefore, due to this automation the treatment is become more easy, effective and efficient.
- **End of Life Care:** By using these applications, devices the user is comfortable and confident about their health care. Therefore, this type of applications are popular and in demand.
- **Research:** - The research on this field is also using the various AI enable resources to make effective and efficient outputs. Due to available virtual environment the various medicines are evaluated and according to feedback the improvement will be taken place.

The paper is organized in a way where the section 2 is explain the available literature and text. Which is important to analyze the work done so far. Further Components for the development of the AI enabled wearable devices are explained with analysis of the available documents. And finally, the conclusion is there to summarize the work of the manuscript.

Literature Survey

For certain activity situations, for example, implantable gadgets and urgent security/wellbeing checking, wearable hardware/pho-tonics that can work autonomously and economically are profoundly requested. As the current fuel sources, that is, batteries, ordinarily accompany cumbersome occupation, substantial weight, inflexible structure, and restricted life expectancy, a more supportable arrangement is direly wanted in the time of IoT and 5G. Profited by the fast advancement of energy gathering and capacity, wearable gadgets, and frameworks furnished with these trend setting innovations are accepting expanding consideration and considered as a promising arrangement with potential self-support ability. Generally talking, piezoelectric, triboelectric, thermoelectric, and photovoltaic based energy collectors and self-controlled (i.e., self-created) sensors/actuators have brilliant similarity with wearable hardware and are in this way broadly adopted. The examination of sustainable force sources and self-fueled hardware/pho-tonics in wearable frameworks has pulled in worldwide exploration interests and exertion to accomplish higher yield execution and transducing efficiency.[15][16]

As of date, the innovation combination of the arising man-made reasoning (AI) with useful gadgets, has supported another region of insightful frameworks that can recognize, dissect, and settle on choices with AI helped algorithms.Furthermore, profited by the 5G organization, the

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procurement pace of detecting information can fulfill the prerequisites of large information investigation and higher types of AI.[17] Besides, AIoT (AI + IoT) in light of the aggregate mix of AI and IoT has likewise arisen and been considered as the cutting edge innovation to empower savvy environments in expansive IoT applications.[18] When consolidating wearable hardware/photonics with AI innovation, the resultant wearable frameworks can play out a more confounded and extensive examination on the gained informational collections (preparing sets) past the ability of ordinary approaches.[19]

At that point this prepared model can be utilized to anticipate the order of the new approaching information, going about as the molding to trigger a planned occasion. The exactness of forecast can be improved through picking appropriate algorithms, tuning the boundary algorithms, and melding various kinds of information from broadened sensors. [20]Essentially, the insightful frameworks can change the method of detecting and communication, with a wide scope of utilizations in cutting edge character acknowledgment, customized medical services checking and therapy, brilliant home/office/building, shrewd IoT, encoded cooperation's in computer generated simulation (VR) and expanded reality (AR) climate, thus on.[21]As indicated by the new advancement of wearable gadgets/photonics and frameworks, the introduced work here supportive of vides a perfect diagram of this field in the parts of arising materials[22]–[24], transducing instruments, underlying setups, viable applications, and cutting edge innovation combination. [25]To start with, improvement of general wearable gadgets/photonics is summed up for the applications in physical/synthetic detecting, human-machine association, show, correspondence, etc. Second, self-supportable wearable hardware/photonics and frameworks with coordinated energy gathering and capacity innovations are introduced. Third, innovation combination of wearable frameworks and AI is audited, indicating the rise and quick advancement of canny/savvy frameworks. Eventually, points of view about the improvement patterns of the cutting edge wearable gadgets/photonics are supportive of vided, that is, advancing toward multifunctional, self-reasonable, and wise wearable frameworks in the AI/IoT era.[26]

In the new period of web of things (IoT) and fifth-age (5G) remote networks, gigantic generally appropriated electronic gadgets including wearable hardware/photonics are required to be interconnected remotely with super quick information swapping scale, giving ongoing correspondence about what we need to know (data about the human body and surrounding climate) and what we need to do (cooperation and intercession). Under a comparable extension, the idea of body territory sensor organization (bodyNET) is likewise proposed by hybridizing various wearable gadgets around the human body, focusing on the applications in customized medical services and multifunctional robotics. For certain activity situations, for example, implantable gadgets and urgent security/wellbeing observing, wearable hardware/pho-tonics that can work autonomously and reasonably are exceptionally requested. As the current fuel sources, that is, batteries, ordinarily accompany cumbersome occupation, substantial weight, inflexible

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structure, and restricted life expectancy, a more feasible arrangement is desperately wanted in the period of IoT and 5G. Profited by the fast advancement of energy gathering and capacity, wearable gadgets, and frameworks outfitted with these trend setting innovations are getting expanding consideration and considered as a promising arrangement with potential self-support ability. Generally talking, piezoelectric, triboelectric, thermoelectric, and photovoltaic based energy reapers and self-fueled (i.e., self-created) sensors/actuators have superb similarity with wearable hardware and are hence broadly adopted. The examination of sustainable force sources and self-controlled gadgets/pho-tonics in wearable frameworks has pulled in worldwide exploration interests and exertion to accomplish higher yield execution and transducing efficiency.[27]The innovation combination of the arising computerized reasoning (AI) with utilitarian hardware, has supported another zone of wise frameworks that can distinguish, dissect, and settle on choices with AI helped algorithms.Furthermore, profited by the 5G organization, the procurement pace of detecting information can fulfill the necessities of large information investigation and higher types of AI. Besides, AIoT (AI + IoT) in view of the aggregate reconciliation of AI and IoT has likewise arisen and been considered as the cutting edge innovation to empower insightful environments in wide IoT applications. When joining wearable gadgets/photonics with AI innovation, the resultant wearable frameworks can play out a more convoluted and exhaustive examination on the gained informational collections (preparing sets) past the capacity of customary approaches.[28]At that point this prepared model can be utilized to foresee the arrangement of the new approaching information, going about as the molding to trigger a planned occasion. The exactness of forecast can be improved through picking appropriate algorithms,tuning the boundary of algorithms, and combining various sorts of information from enhanced sensors.On a very basic level, the wise frameworks can change the method of detecting and association, with a wide scope of utilizations in cutting edge character acknowledgment, customized medical care checking and therapy, shrewd home/office/building, savvy IoT, encoded connections in computer generated simulation (VR) and increased reality (AR) climate, thus on. As indicated by the new advancement of wearable gadgets/photonics and frameworks, the introduced work here supportive of vides a fortunate diagram of this field in the parts of arising materials, transducing instruments, underlying designs, useful applications, and cutting edge innovation combination. To start with, improvement of general wearable gadgets/photonics is summed up for the applications in physical/compound detecting, human-machine collaboration, show, correspondence, etc. Second, self-supportable wearable hardware/photonics and frameworks with incorporated energy gathering and capacity advances are introduced. Third, innovation combination of wearable frameworks and AI is explored, indicating the rise and fast improvement of keen/brilliant frameworks. Eventually, viewpoints about the improvement patterns of the cutting edge wearable hardware/photonics are supportive of vided, that is, enhancing toward multifunctional, self-reasonable, and savvy wearable frameworks in the AI/IoT era.[29]

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Components for the development of the AI enabled wearable devices.

The advancement of adaptable and delicate materials is fundamental for wearable gadgets in light of their extraordinary compound, electrical, and mechanical properties. Conventional materials for wearable gadgets are generally metals and semiconductors with moderately poor mechanical adaptability and stretch ability. Recently, natural or polymeric materials are acquiring consideration from the local area because of their boss mechanical flexibility.[30]

A strain sensor and supercapacitor is created with wrinkled CNTs as the conductive layer and designed polydimethylsiloxane (PDMS) as the delicate substrate, by a straightforward and ease manufacture measure as in Figure 2. [31]

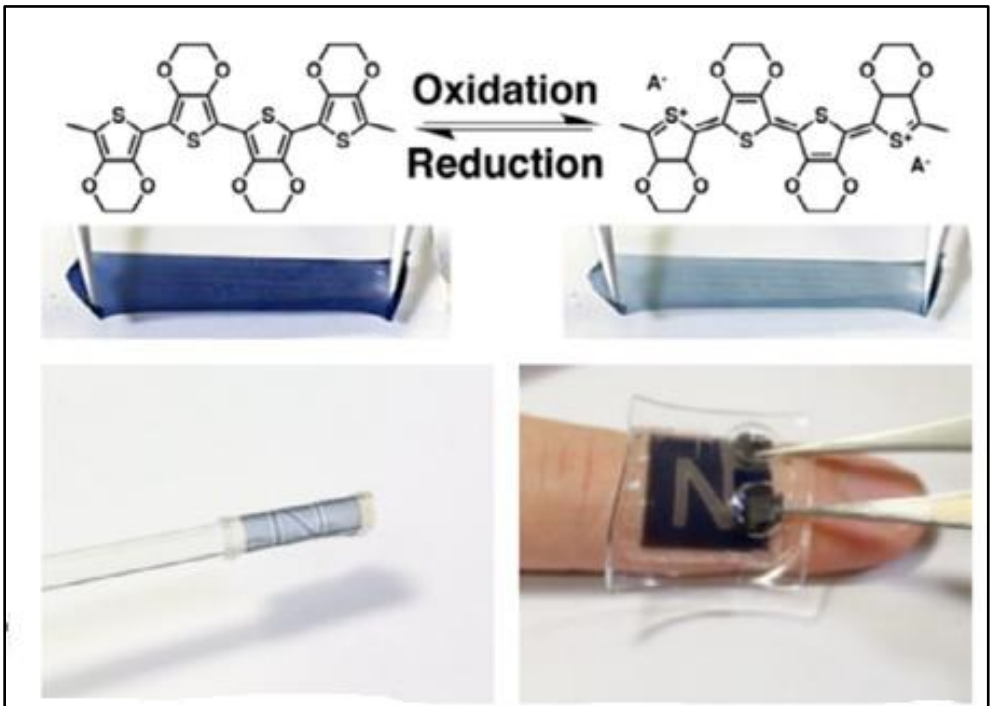

Figure 2: The naturally stretchable, PEDOT electrochromic film [31]

The comparing examining electron magnifying instrument (SEM) pictures of the crumpled CNT sheets on the PDMS film are appeared in Figure-3[32] also. Concluded the incorporation of the exceptionally conductive CNT sheets and the flexible PDMS layer, aamalgamated film with great conductivity and flexibility is illustrated.

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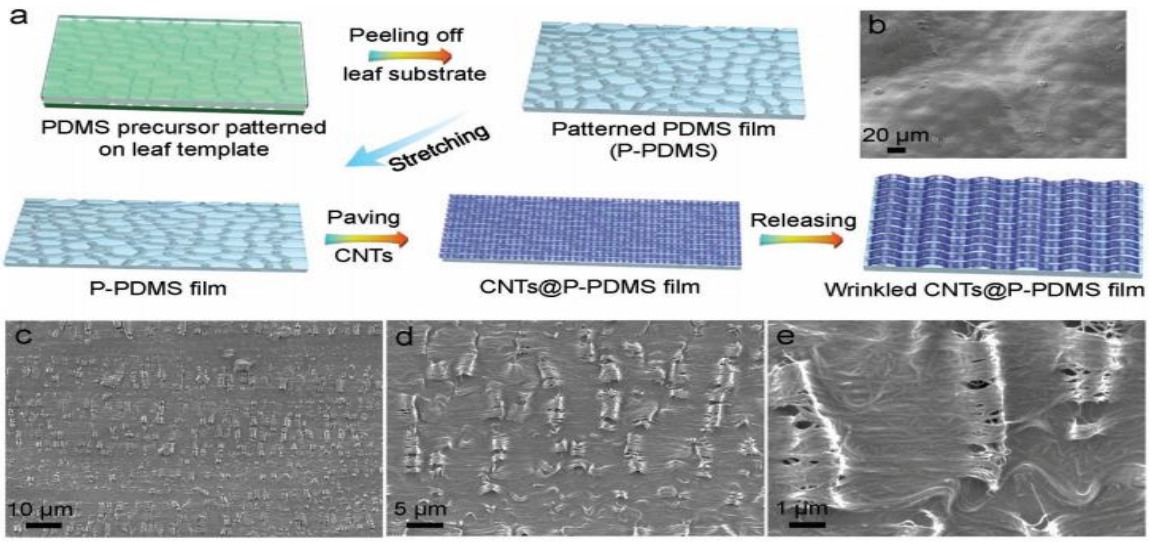

Figure 3: Adaptable film containing conductive crumpled CNTs films[32]

Notwithstanding those regularly utilized materials, hydrogels speak to a special class of materials that have particular electrochemical appropriate binds, for example, their capacity to lead the two particles and electrons, conductivity and grip, as appeared in Figure 4Its momentous self-recuperating property after cutting-instigated break has additionally been effectively illustrated, demonstrating an incredible capability of particle gel materials in different biomedical applications sooner rather than later.[33][34]

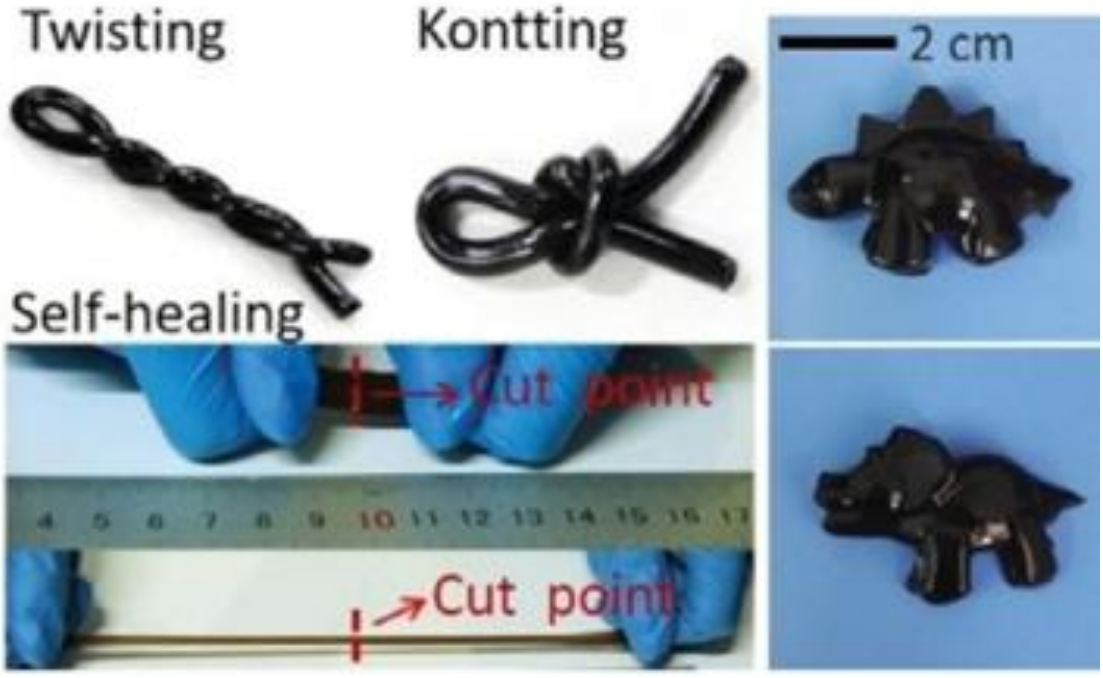

Figure 4: Stretchable, self-mending, and glue particle gel nanocomposites for strain detecting.[33][34]

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Actual detecting is perhaps the most central capacities needed for wearable gadgets to screen various types of physiological signs. Customary transducing instruments embraced generally incorporate resistive detecting and capacitive detecting. Other than the previously mentioned two well known techniques, slim movie semiconductors can likewise be actualized as detecting components for direct power checking. It is considered as another pressing factor detecting method that empowers the utilization of small detecting components with high affectability and huge territory adaptability underway. A zinc oxide dainty film semiconductor working as both a semiconductor and a power sensor with a similar gadget structure is introduced. Besides, a sensor cluster with the power detecting semiconductors is manufactured without extra tending to components. [35]

For the far reaching uses of wearable actual sensors, observing the fundamental indications of people is vital, for example, blood pressure,beat (heart rate),and breathing rate (respiratory rate). As shown in Figure 5,[36] adaptable pressing factor sensors are joined to the wrist and the bosom for recording the epidermal heartbeat and breath rate/pulses, individually, giving abundant data about the wellbeing status of the subject.[37]

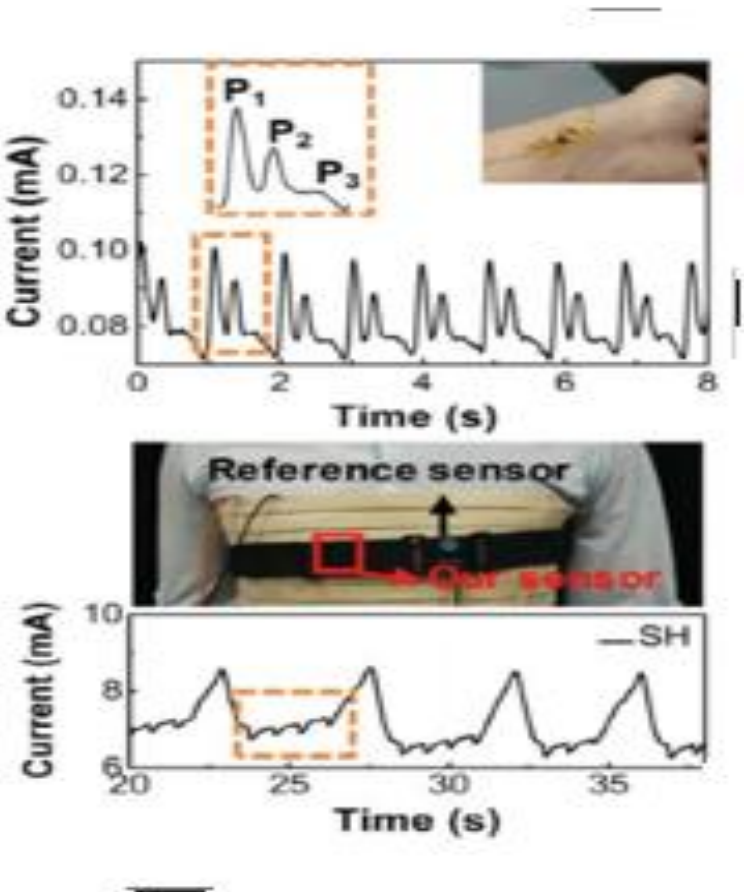

Figure 5: Schematics of the detecting instrument of a capacitive pressing factor sensor with miniature designed structures.[36]

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Likewise, catching body movements with the wearable strain sensors on different body parts is additionally practical, as portrayed This pressing factor heartless strain sensors are manufactured utilizing an all-arrangement measure, and have high detecting selectivity of applied strain over pressing factor. By collecting them on fingers and knees, the bowing movements of separate parts can be consistently checked. Furthermore, epidermal gadgets with the ability of estimating warm properties of human skins have pulled in wide consideration because of the gave bits of knowledge of actual changes firmly identified with blood perfusion, hydration, and different pathologies. A remote and sans battery sensor that delicately interfaces with skin is accounted for to empower exact checking of the skin temperature and warm vehicle properties (Figure 6). Moreover, the sensor is additionally ready to screen vascular perfusion varieties[38][39]

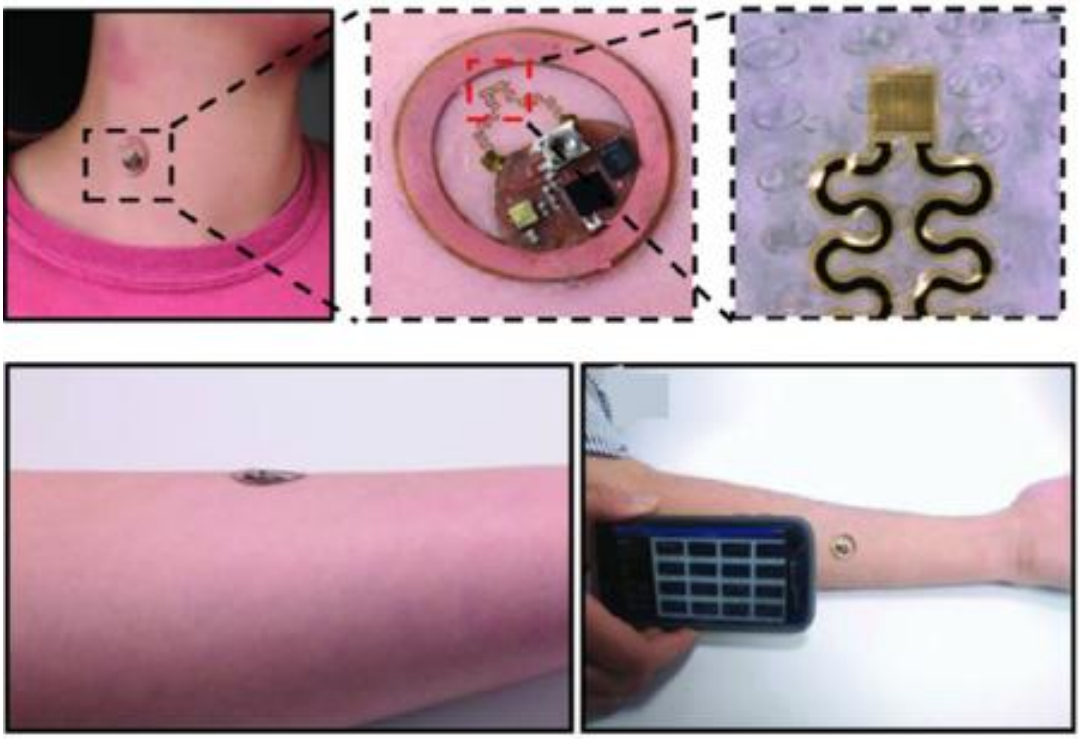

Figure 6: Remote and without battery epidermal gadgets for exact and quantitative warm portrayal of human skin.[38][39]

Analysis of the available documents

The depth and thrust of any topic and field can be known only through the study and analysis of the available literature. The upcoming sections are explaining and analyzing the available literature.When we search the documents for the AI enabled wearable devices then only 16 documents are available in the SCOPUS database. It shows the thrust in this area. While searching the wearable devices then 35519 documents are searched in SCOPUS database.[40]

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Available Document per Year

Major contribution related to the research in the field of Software Bug, its fixing techniques, testing, and other related task is reported from 1970. But since 2002, good amount of the research articles have been reported in literature. The details of the documents available in literature is shown in Table-1

Table-1 Year wise details of the available literature

Year	Documents
2021	448
2020	6215
2019	6571
2018	5469
2017	4304
2016	3358
2015	2590
2014	1396
2013	880
2012	568
2011	609
2010	510
2009	432
2008	391
2007	359
2006	271
2005	283
2004	188
2003	145
2002	102
2001	87
2000	75
1999	64
1998	31
1997	53
1996	21
1995	11
1994	12
1993	6
1992	5
1991	10
1990	2

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1989	1
1988	7
1987	6
1986	7
1985	7
1984	8
1983	2
1982	3
1981	0
1980	1
1979	2
1978	1
1977	2
1976	1
1975	2
1974	1
1973	1
1972	0
1971	0
1970	1

The analysis of the available document with respect to year has been illustrated in Figure-7.

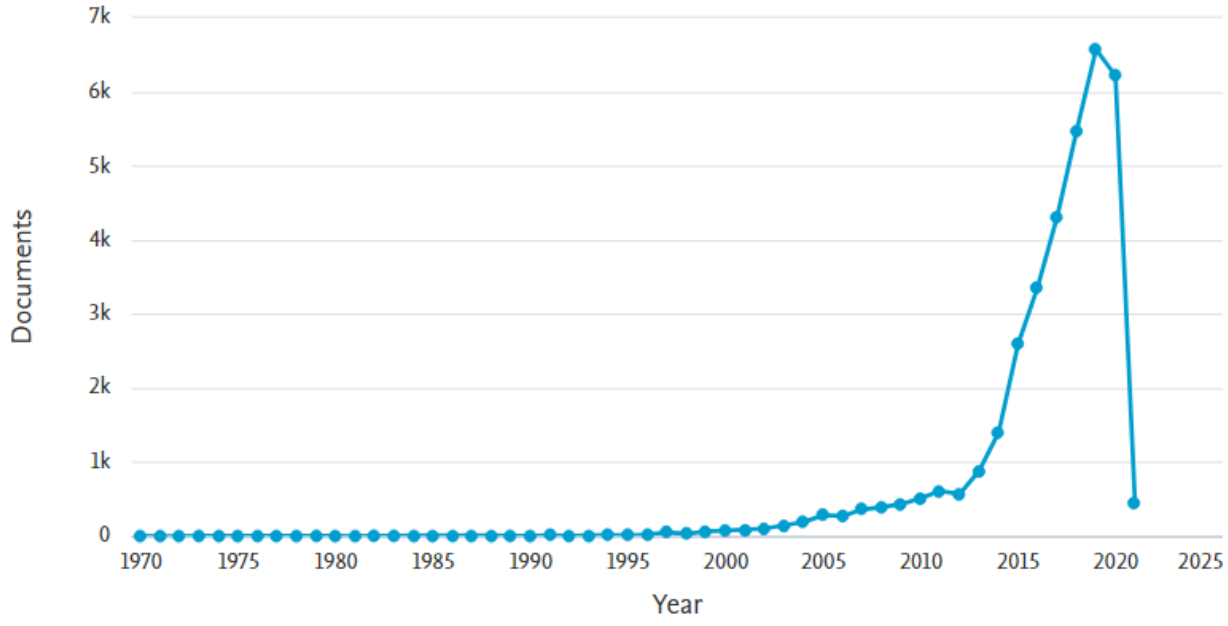

Figure 7 : Graph about the documents available year wise

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Major Contributor in the research field

It has been observed that China took lead in this field. Top contributor universities are from China which are list in the Table-2. Therefore United States has been done research in software-bug and it's related various field to manage the things securely and transparently. It is important for all the business working on Information and Communication Technology like health sector, manufacturing, sales, etc.

Table-2 Top list of Affiliation wise details of the available literature

Affiliation	Documents
Chinese Academy of Sciences	1093
Ministry of Education China	780
Tsinghua University	496
Georgia Institute of Technology	466
University of Chinese Academy of Sciences	393
Korea Advanced Institute of Science & Technology	373
Nanyang Technological University	310
Massachusetts Institute of Technology	305
National University of Singapore	302
The University of Tokyo	289

The results are also be analyzed through the bar chart as shown in the figure-8.

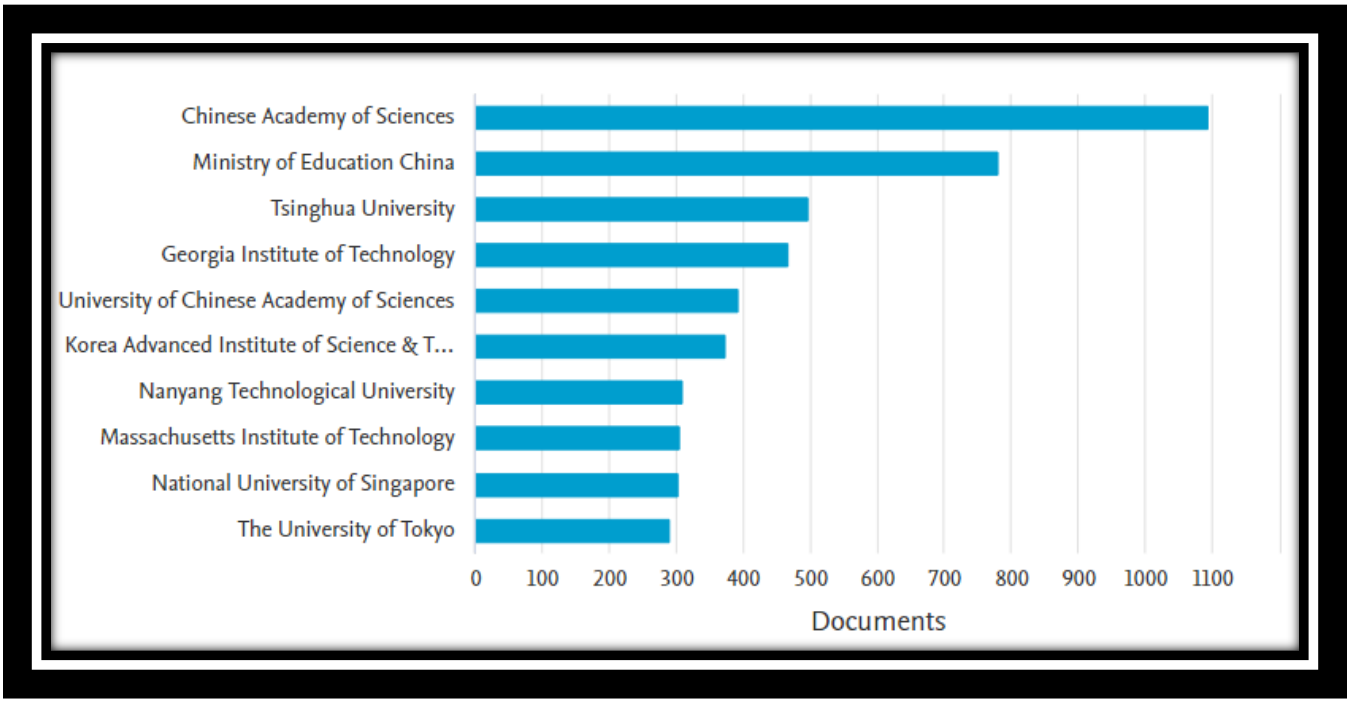

Figure 8 : Statistical representation about the documents with respect to affiliation

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Top Countries working in this research field

While analyzing the available literature in this field, it has been overserved that, top 10 countries are United States, China, India, Germany, Canada, United Kingdom, Australia, Japan, Germany, Italy, and so on. The documents numbers as per SCOPUS are analytically represented in table.

Table-3 Country wise details of the available literature

Country/Territory	Documents
United States	8711
China	6835
South Korea	2871
Japan	2521
United Kingdom	2421
Italy	2328
India	1650
Germany	1594
Australia	1300
Canada	1218

The statistical representation of the data is illustrated in Figure-9 , where the longest bar is of United States and shortest is of Canada.

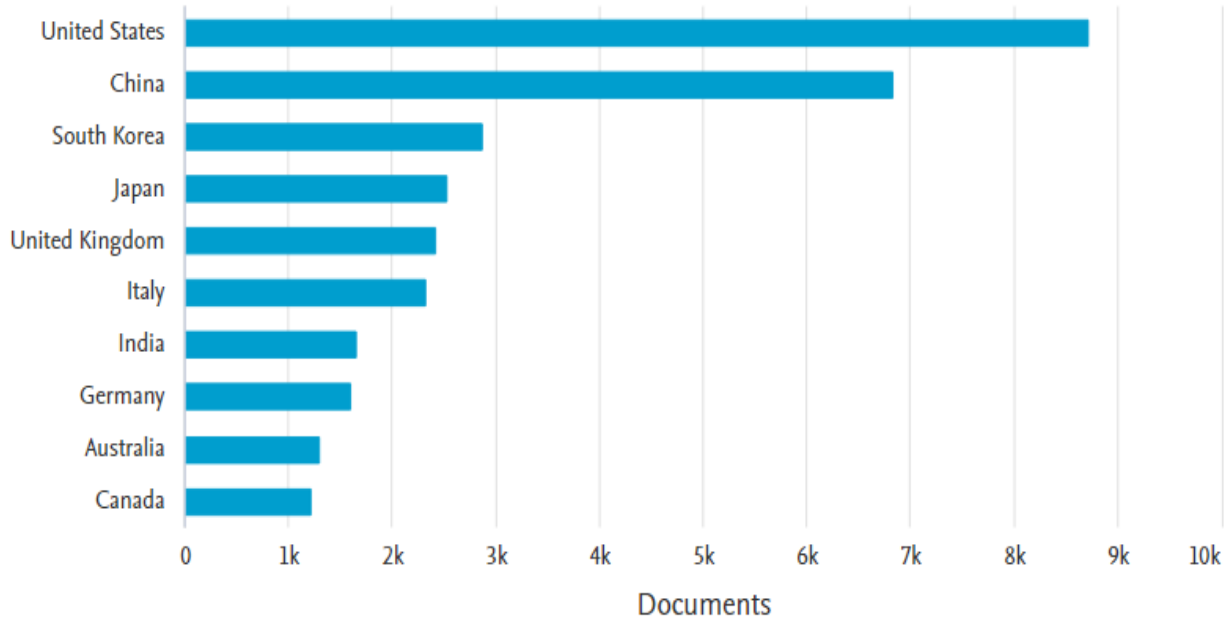

Figure 9 : Graphical analysis of available literature documents in this field

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CONCLUSION AND FUTURE SCOPE

As per the new advancement of wearable gadgets/photonics, the progression of the cutting edge wear-capable hardware and photonics will be proceeded toward frameworks with multifunctionality, self-manageability, and higher insight. Most importantly, more functionalities are required to be incorporated into one wearable gadget to accomplish higher efficiency. In such manner, a significant exploration bearing in this field is to imitate the somatosensory arrangement of human skin utilizing precisely adaptable/stretchable sensor organizations (otherwise called electronic-skin or mechanosensation hardware) that could distinguish and measure various outer upgrades, including yet not restricted to pressure, strain, temperature, stickiness, light, etc. As of late, an exceptionally stretchable grid with coordinated multi-sensors on a polyimide network was effectively evolved to accomplish numerous detecting functionalities, for example, pressure, in-plane strain, temperature, stickiness, light, attractive field, and vicinity. With the incorporation of half and half energy collectors and capacity units in wearable frameworks, accessible energy, for example, contact, vibration, warmth, and light in the encompassing environmental factors can be viably rummaged by various transducing components. To wrap things up, the prosperous improvement of AI and wearable gadgets/photonics has encouraged the rise of a pristine exploration territory, that is, canny/keen wearable frameworks, with wide applications in customized medical services observing and therapy, character acknowledgment, brilliant home/office/building, and insightful collaborations in VR/AR climate, etc.

As far as the future scope is concern, profited by novel AI calculations during the time spent information investigation, the insightful frameworks can naturally remove basic highlights with inner connections from the muddled and assorted tactile signs. Through coordinating a specific utilitarian framework with a legitimate AI model, more complete data can be separated for later personality acknowledgment and dynamic, prompting exceptionally canny/brilliant wearable frameworks. In rundown, the improvement patterns of the cutting edge wearable gadgets/photonics will be ceaselessly cutting-edge toward multifunctional, self-supportable, and smart frameworks in the time of AI/IoT. As discussed above, we need the huge workforce to handle the health issues specifically after seeing the pandemic like COVID-19. To overcome this time of situations, we need to develop more and more AI enable devices, techniques and procedures to help the patients to cure and overcome from the various health disease.

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