Telemedicine

Chapter 5

Smart@Iot Ai-Iot Healthcare Solution in Smart Homes Environment Telemedicine

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1. Research Project Background

1.1. Artificial intelligence in healthcare

AI has been in development for decades, but only recently gotten good enough for people to notice, mostly due to advances in other industries besides health care.

Intelligent computing/AI uses algorithms, heuristics, pattern matching, rules, machine/deep learning, and cognitive computing to solve problems typically performed by humans, as well as complex problems difficult for humans.

The rise of intelligent machines is approaching; and the world, especially the health care industry, is far from prepared for what's to come.

Benefits of Intelligent Computing/AI: Realize the value of Health-IT, it creates different kinds of values of benefits to patients, healthcare, providers and communities, Tasks get done faster and more consistently • Enhances the abilities of human workers • Interacting with AI can be fun! • Clinicians have smart "assistants" they can query • Stuff doesn't' fall "through the cracks" • Larger and more complex data sets can be accessed • Analytics can be made smarter • Alerts and reminders can be more intelligent • Supports more dynamic and adaptive patient engagement • Catches problems and trends earlier • Adapts education to the patient and context • Reduces labor costs • Operates continuously and with more capacity • Becomes more effective over time.

1.2. Internet of things (IOT) in healthcare

In the Internet of Things (IoT), devices gather and share information directly with each other and the cloud, making it possible to collect, record and analyze new data streams faster and more accurately. That suggests all sorts of interesting possibilities across a range of industries: cars that sense wear and tear and self-schedule maintenance or trains that dynamically calculate and report projected arrival times to waiting passengers. But nowhere does the IoT offer greater promise than in the field of healthcare, where its principles are already being applied to improve access to care, increase the quality of care and most importantly reduce the cost of care. At Freescale, we're excited to see our embedded technologies being used in applications like telehealth systems that deliver care to people in remote locations and monitoring systems that provide a continuous stream of accurate data for better care decisions. As the technology for collecting, analyzing and transmitting data in the IoT continues to mature, we'll see more and more exciting new IoT-driven healthcare applications and systems emerge. Read on to learn what's happening now-and what's on the horizon-for healthcare in the age of the IoT. The emergence of the IoT, in which devices connect directly to data and to each other, is important for two reasons:

1. Advances in sensor and connectivity technology are allowing devices to collect, record and

analyze data that was not accessible before. In healthcare, this means being able to collect patient data over time that can be used to help enable preventive care, allow prompt diagnosis of acute complications and promote understanding of how a therapy (usually pharmacological) is helping improve a patient's parameters.

2. The ability of devices to gather data on their own removes the limitations of human-entered data-automatically obtaining the data doctors need, at the time and in the way they need it. The automation reduces the risk of error. Fewer errors can mean increased efficiency, lower costs and improvements in quality in just about any industry. But it's of particular interest/ need in healthcare, where human error can literally be the difference between life and death.

1.3. Clinical care

Hospitalized patients whose physiological status requires close attention can be constantly monitored using IoT-driven, noninvasive monitoring. This type of solution employs sensors to collect comprehensive physiological information and uses gateways and the cloud to analyze and store the information and then send the analyzed data wirelessly to caregivers for further analysis and review. It replaces the process of having a health professional come by at regular intervals to check the patient's vital signs, instead providing a continuous automated flow of information. In this way, it simultaneously improves the quality of care through constant attention and lowers the cost of care by eliminating the need for a caregiver to actively engage in data collection and analysis.

1.4. Remote monitoring

There are people all over the world whose health may suffer because they don't have ready access to effective health monitoring. But small, powerful wireless solutions connected through the IoT are now making it possible for monitoring to come to these patients instead of vice versa. These solutions can be used to securely capture patient health data from a variety of sensors, apply complex algorithms to analyze the data and then share it through wireless connectivity with medical professionals who can make appropriate health recommendations.

1.5. Edge computing survey papers: Tarik Taleb et al [7]: Year of Publication: 2017

This research work is a survey on MEC (Mobile Edge Computing) that discusses the major enabling technologies in this domain. It explores MEC deployment considering both the perspectives of individual services as well as a network of MEC platforms supporting mobility. Different possible MEC deployment options are also discussed here. It also delves into analysis of a MEC reference architecture and its main deployment scenarios that can offer multitenancy support for application developers, content providers, and third parties. This work also details out the current standardization activities and future open research problems.

Somayya Madakam et al [24]: Year of Publication: 2015

The main objective of this work is to provide an overview of Internet of Things, architectures, and vital technologies and their usages in our daily life. Major observations made in this document are

a. There is no standard definition of IoT

b. Universal standardizations are required in architectural level

c. Technologies are varying from vendor-vendor and hence there is a need of interoperability.

d. For better global management, there is a need to build standard protocols.

Koustabh Dolui et al [34]: Year of Publication: 2017

This work explores the efficacy of different types of Edge computing models namely Fog Computing, Cloudlet and Mobile Edge computing and compares their feature sets. With lot of attention towards IOT and applications that need Real Time Reponses, edge computing has become an area of interest for researchers.

Yuyi Mao et al [40]: Year of Publication: 2017

This paper provides a survey on the state of art technologies for Mobile Edge computing with a focus on optimization of radio (network) and computational resources.

1.6. IOT Applications in Healthcare: Vikas Vippalapalli et al [16]: Year of Publication: 2016

This proposal is for a low-cost patient healthcare monitoring system model based on lightweight wearable sensors. These sensing nodes are used for real time detection and analysis of healthcare data of patients. The devices are designed to be able to collect and share the gathered data among themselves thereby facilitating information analysis and storage. This also eliminates manual in-efficiencies in the process. For patient data collection, a Audrino based wearable device with Body Sensor Networks is proposed. This is integrated with "Labview" to provide remote monitoring capability.

Maheswar Rao Kinthada et al [17]: Year of Publication: 2017

This research proposes a method/framework that can be used to monitor patients medicine intake. It provides a mechanism to dispense prescribed medications as well as track medication history including International Journal of Pure and Applied Mathematics Special Issue1475 missed dosage. The framework alerts the patient regarding medication consumption using alarms. In case of failure, medical staff is also made aware of the missed dosage.

UtkarshaniJaimini [18]: Year of Publication: 2017

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R.N.Kirtana et al [19]: Year of Publication: 2017

Heart Rate Variability (HRV) measures variation in time interval between consecutive heart beats. HRV analysis can detect Cardiovascular diseases, Diabetic Mellitus, disease states associated with Autonomic Dysrhythmia like Hypertension and different chronic degenerative medical conditions. Monitoring HRV

data will help detection of such diseases. In this research work, the authors propose a low-cost and easy to use Remote HRV Monitoring System based on Internet of Things (IoT) technology for Hypertensive patients. In this proposal, HRV parameters are calculated based on the data retrieved using Wireless Zigbee based pulse sensor. This Arduino based systems transmits the data retrieved from monitoring the patient to a backend server using MQTT an IOT protocol. The application server collects HRV data and plots graphs.

1.7. Predictive Analytics in Health-Care Decision-Making

Predictive analytics deals with information retrieval to predict an unknown event of interest, typically a future event. Using technology that learns from data to predict these unknown events could drive better decisions.

There are several steps in the predictive analytics process: Identification of the problem and a determination of the outcomes and objectives is a crucial first step. Being able to identify the objective of the problem will aid in determining the appropriate data to use for the model. Data Collection incorporates data mining techniques, which prepare the data for analysis using data storage and data manipulation technologies from multiple sources.

Using sophisticated statistical methods, including multivariate analysis techniques such as advanced regression or time-series models, statistics allow for the exploration of intentional and specific relationships among data. Regression models are among the most commonly used techniques in predictive analytics. These models mathematically describe the relationship between the predictor (explanatory) variable and the outcome variable. Machine learning techniques, another popular method used to conduct predictive analytics, are drawn from a number of fields of study such as artificial intelligence.

Modeling captures patterns and relationships within the data and extrapolates future outcomes based on those patterns and relationships. The main assumption that underlies a predictive model is that a future event will continue as past events have occurred. Some researchers have argued that this assumption is a flaw in the model, as past behaviors do not always predict future behaviors.

2. Line of Products and Services

The Corporation is projecting the design and configuration of Telemedicine Systems with a view towards marketing them in different entities providing specialized Medical Services.

2.1 NEW REAL-TIME INTELLIGENT Fog Assisted- IoT Enabled Patient Health Emergency Prediction and Critical Decisions in Smart Homes

➢ As shown in Figure, Smart@IoT solution will offer the first intelligent healthcare services inside homes, for elderlies, families and emergency care services

➢ Our new artificial intelligent portfolio and software solution will provide Heart/Brain stroke prediction, monitoring and Diagnosis.

➢ Smart@IoT home services will provide as well a mHealth APP to send alerts and notifications to nearest hospital and neighbors

➢ The portfolio will be based on recent technologies of Vodafone (IoT) internet of things, first on targeting marketing and best telecommunication networking in Egypt.

➢ The system will also provide the first novel AI predictive analytics system for all people tracking based on dell IoT gateway and connecting to the American health services (telemedicine) solution on Dell power edge serves inside the hospitals.

➢ Smart@IoT office will also provide different wearable sensors for health, wellness and remote mentoring per single area.

2.2 Artificial Intelligence Predictive Analytics Software for Heart Stroke/Brain Stroke/ Heart Attacks for Smart Homes/ Smart Hospital

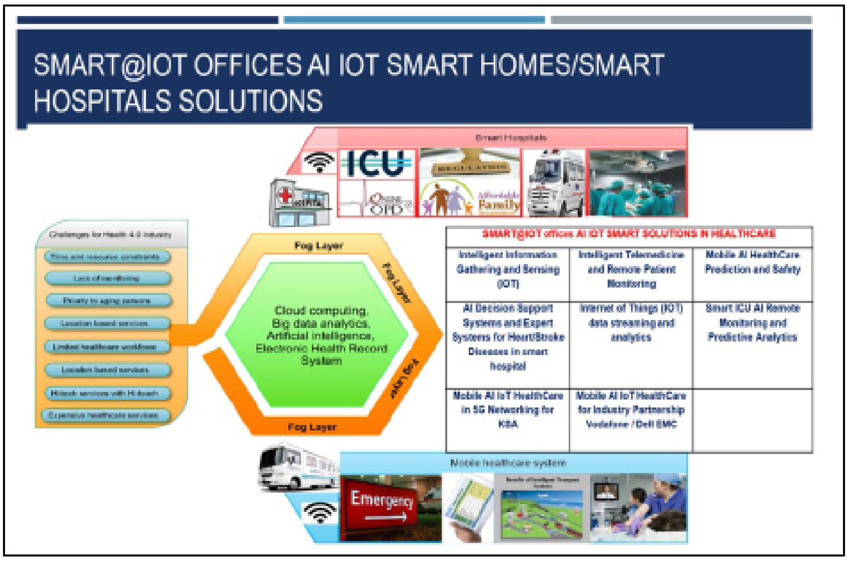
AI Clinical decision support and Predictive analytics

In a similar vein, the industry has high hopes for the role of artificial Intelligence, Predictive analytics and deep learning in clinical decision support and predictive analytics for a wide variety of conditions.

* Deep learning may soon be a handy diagnostic companion in the inpatient setting, where it can alert providers to changes in high-risk conditions such as sepsis and respiratory failure.

* Our International Experts, professors and Researchers in **Smart@IOT Regional offices have more than 15 years experience** in Computer Science and Artificial Intelligence , in the proposed systems, As shown in Figure, we will provide a Complete Integrated Artificial Intelligence/Predictive Analytics Specialized Software Programs along with our systems of **Mobile AI Telemedicine, Smart Home-AI HealthCare Solution, Smart ICU, and Smart Hospitals Unit for Heart/Brain Stroke Diseases Emergency and Monitoring**. Which leverages Deep learning to alert clinicians to patient downturns.

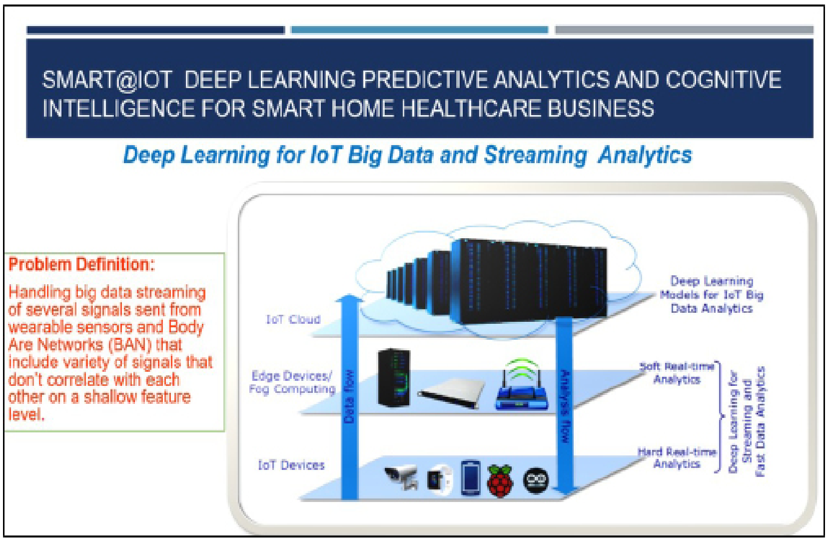
* The set of **NOVEL AI Algorithms** will offer human clinicians a detailed rationale for its recommendations, helping to foster trust and allowing providers to have confidence in their own decision-making when potentially overruling the algorithm. In addition, the system is able to use a single model to predict many outcomes.



Smart@IOT Smart Homes Health will use both Artificial Intelligence (AI) ALGORITHMS and Internet of Things (IoT) technology to provide a competent and structured approach to handle service deliverance aspects of healthcare in terms of Mobile AI health and remote patient monitoring. IoT generates an unprecedented amount of data that can be processed using DELL EMC Machine Learning with Hadoop. But for Real-time remote health monitoring applications, the delay caused by transferring data to the server and back to the application is unacceptable. Relative to this context, we proposed the remote patient health monitoring, critical decisions, prediction in smart homes by using the concept of fog computing at the smart gateway. The proposed Intelligent-IOT model uses advanced Machine Learning and Artificial Intelligence techniques and services such as Mobile Edge Computing, Mobile AI Telemedicine, distributed networking and services and complete Family/Person/Patient

Remote Monitoring and tracking for real-time health conditions and notification services at the edge of the Network and connecting to Nearest Hospital and Doctor Mobile AI Telemedicine. Event triggering based data transmission methodology is adopted to process the patient's real-time data at Fog Layer of the Fog Computing.

-Smart@IOT Artificial Intelligence Algorithms Assists Stroke/Heart Diseases' Prediction. It also uses Deep Learning for IoT Big Data and Streaming Analytics. Moreover, it handles big data streaming of several signals sent from wearable sensors and Body Are Networks (BAN) that include variety of signals that don't correlate with each other on a shallow feature level. The system is scalable to many diseases predictions using wearable sensors technologies for patients and wellness, the different sensors can be used as illustrated in the figure below.

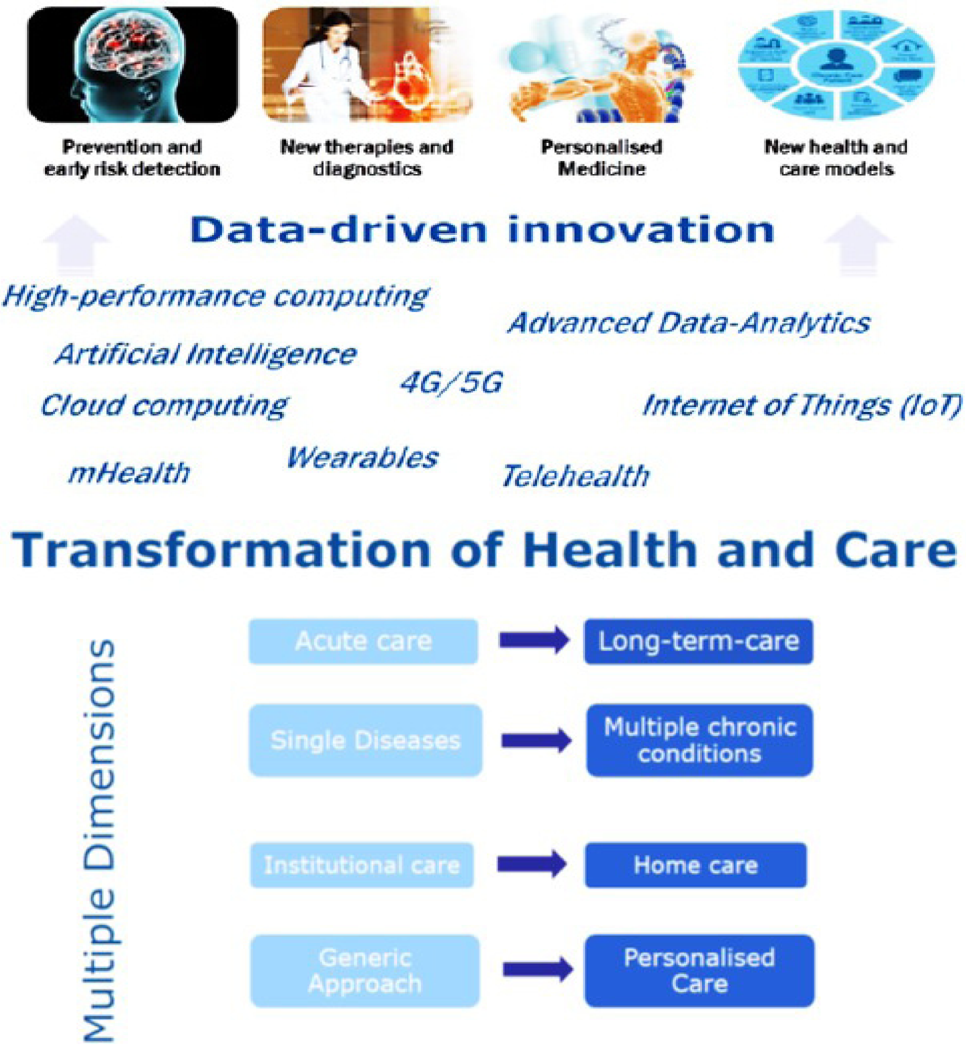


SMART@IOT WEARABLE SENSORS SCALABILITY SOLUTIONS FOR HEALTH AND WELLNESS

Medical condition	Type of sensor	Data rate	Description
Muscular atrophy	Accelerometer/gyroscope	35kbps	Faulty postures and movements
Diabetes	Blood glucoseâ€	1600bps	Blood glucose levels post partum and fasting
Cardiac, hypertension	Blood pressure	1000bps	Non invasive systolic, diastolic and venous pressure
Pulmonary, Asthma	CO2 gas sensor	10kbps	Carbon dioxide and oxygen content in the blood
Cardiac arrhythmias and other abnormalities	ECG sensor	12 lead:288kbps, 6lead:71kbps	Electrical activity of the heart
Neurological	EEG sensor	86.4 kbps, deep brain stimulation: 1Mbps	Electrical activity of the brain
Neuromuscular abnormalities	EMG sensor	1.536Mbps	Electrical activity in response to a nerve's stimulation of the muscle

3. Conclusion and Scope

R&D Artificial Intelligence, IoT, Telemedicine and Big Data Analytics for Elderly People, Chronic Conditions for Smart Health Living at Homes.



Challenge

• Citizens at greater risk of cognitive impairment, frailty and multiple chronic health conditions with considerable negative consequences for their independence, quality of life and for the sustainability of health and care systems;

• Foster large-scale deployment of integrated digital solutions, which will bring improved quality of life to citizens while demonstrating significant efficiency gains in health and care delivery across Europe.

Scope

• Platform for smart living should integrate a mix of advanced ICT ranging from biophotonicsto robotics, from artificial intelligence to big data and from IoT to smart wearables

• Pilots to build on open platforms, standardized ontologies, APIs and results from IoT-based smart living environments, service robotics and smart wearable & portable systems

• Go beyond current state of the art in terms of scale, the capabilities for personalization, adaptation, and user acceptance.

One of two Areas can be addressed:

1. Intelligent and personalized digital solutions for sustaining and extending healthy and independent living support to older individuals at risk of temporary or permanently reduced functionality and capabilities.

2. Personalized early risk detection and intervention Innovative solutions for prevention and treatments based on early risk detection for people facing increased health and social risks.

• Cover the supply and demand sides

• Clear methodology and impact indicators for socio-economic impact assessment from using the platform, where possible using the MAFEIP framework

• Demonstrate feasibility of integration with other relevant application domains such as energy, transport, or smart cities, including interoperability, along with data security and integrity

• Minimum of 4 pilot sites in 4 countries.

Impact

- Emergence of European-led platform for smart and healthy and independent living at home;

- Increased competitiveness of the European ICT industry in the domain, through enhanced interoperability, best practices for viable business and financing models and scalable markets;

- Demonstrate links and build synergies with Member States' and regional initiatives in this area;

- Improved and evidence-based efficiency of health and care systems with demonstrated added-value of underlying technologies;

- Improved quality of life and health status for involved users and careers, with demonstrated added-value of underlying technologies;

- User accepted, validated innovative solutions addressing accessibility, privacy, security, vulnerability, liability, and trust in connected data spaces.

For Patients: Stroke is a leading cause of disability in the world, and yet AI-Decision Support Systems, Mobile Edge Computing, and telemedicine technology will be available for individuals with stroke to practice, monitor rehabilitation therapy, and Prediction of Emergency cases. A Complete Mobile AI Telemedicine in Smart Homes/Smart Hospitals will use common technologies that provide conduit for tele-consultation exchange between physicians, nurses and patients.

Network Time Measurements:

Operation	Time Cost (Seconds)
Feed forward during training	0.152 Seconds
Total Training for 500 Epochs	240 Second (4 Minutes)
Sample Extraction and Prediction	0.025 Second
10 Million Samples on 8 Nodes	25 Seconds per Node

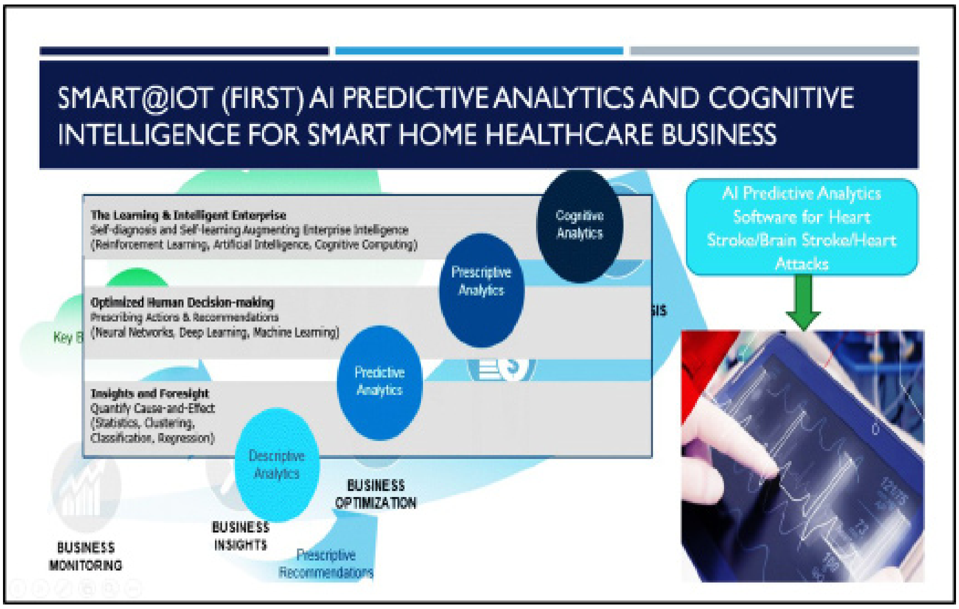
framework	Time to train	Inference time	Achieved Validation Accuracy	Number of GPUs	Scaling Efficiency
Keras	2 mins	40 us	98%	1	-
Keras + Tensoflow	2.3 mins	45 us	97.96%	2	88.88%

For Smart Homes Families: The system can also respond by immediate recommendation and sends patient/Family member data to responsible doctor or nurse and thus save immediate patients , families lives in case of emergencies of heart/Stroke diseases, which will be connected by Nearest-Hospital in less than **ONE HOUR for Direct Pre-Diagnostic Procedures**. As our Recent Research on **Deep Learning algorithms** achieved high accuracies in 25 seconds, along with the Top advanced AI Dell EMC servers for Fast Processing of Data and Fast Automatic queries responding from Smart Hospital Location.

4. Comparison and Analysis of Competition

"Nvidia AI experts and Scripps researchers and clinicians will use deep learning and, more broadly, machine learning, to tackle the deluge of genomics and sensor data. Genomics data is doubling every seven months. To keep up, the team will develop deep learning approaches to help improve mutation detection and make genome sequencing more affordable and accessible," Nvidia said.

SMART@IOT AI Algorithms are independent on Genomic sequence data. However, it purposes a technology based on Wearable sensors and the Novel AI technologies in real-time processing and much more faster. Smart@IoT solutions uses Cognitive Intelligence, Computational Intelligence techniques, Predictive analytics into the Business insights and Business Benefits.



For Patients

- Availability of consultations with Specialists without moving from their locality.
- Transportation to Specialized Medical Centers is avoided, with the consequent savings in transportation, accommodation and no loss of productive time, except in cases of emergency.

- Timely and convenient control of their chronic medical condition, as well as monitoring the evolution of their disease for better control.
- Improvement of quality of life in rural communities or those with low population density.
- High local socio-economic impact.
- The elderly and infant population will have direct access to high quality diagnostic and control tests.
- Pregnant patients will have access to evaluation with state-of-the-art technology for surveillance and control of their pregnancy with the direction of a specialist. There will also be diagnostic capacity for diseases specific to women.

For General Practitioners

- They will have technological resources at their disposal enabling them to evaluate cases better.
- They will maintain direct contact with specialists for better treatment and control of diseases.
- It will enable Continuing Medical Education.
- It will create incentives in medical practice with an increase of local clientele.
- Substantial decrease of unnecessary referrals to medical centers.

For Hospitals and Specialists

- It will Increase the number of visits.
- It will decongest medical offices.
- It will enable professional presence in locations distant from their local areas. Brand penetration.
- The technology will help to keep medical practices organized.
- Efficient and timely monitoring of high complexity patients, which increases customer trust and loyalty, while increasing turnover.

Analysis of the Competition

It has been determined that most of the competition offers services based on a technical vision of IT professionals, experts in hardware and software, as well as pre-configured systems, without taking into account the reality of developing medical consultation in different environments and needs. Therefore, DRN proposes the establishment of telemedicine systems with distinctive elements, based on previous audits of the locality, morbidity, communications, personnel, infrastructure and other aspects that enable the configuration of appropriate systems for those circumstances, as well as on-site installation according to universally accepted medical criteria.

Among the most relevant competitors are Cisco, GlobalMed, AMD Telemedicine, TMA Medica, US Telemedicine, Temondis, Polycom, and other small and medium-sized businesses. CISCO offers a wide range of Telepresence® hardware and software to provide medical care at remote sites and minimize the distance between patients in those areas and medical specialists.

DRN has the VISION of starting operations with a well-implemented structural platform with technological elements and personnel in line with its initially proposed market targets, to market their products and services competitively and in a financially viable way, to gain market shares based on quality, prices and service.

FIELD OF APPLICATIONS

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