A Clinical Decision Support System for Managing Stress

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ABSTRACT

Stress is a silent killer that forms part of everyday life of humans. Stress Overload has a lot of negative effects which include–hypertension, stroke, dysfunction of body systems, poor performance, heart failures and sudden death in some cases. Most people have stress without cognitive notice of being stressed up. Diagnosing stress has been one of the major issues in health sector because it has multiple symptoms. Biomedical Signal devices such as ECG(Electrocardiogram) are being used for the purpose of diagnosing stress and most available Computer Aided Diagnostic Systems for managing stress rely heavily on these devices which are not common especially in rural areas, difficult to handle and also very expensive. These among other reasons have led to many undiagnosed cases of stress. In this work, we have presented a simple effective Clinical Decision Support System to manage stress. The system carries out diagnosis of stress without the use of these expensive devices. This system is a product of consultation with medical experts on stress management and it is hoped that this initiative will be of immense benefit to human race.

Keywords: Diagnosis, Treatment, Stress, Artificial Intelligence, DSS

1. INTRODUCTION

Medical Knowledge is today expanding rapidly to the extent that even expert have difficulties to follow all new results, changes and new treatments. Computer surpasses humans in the ability to remember and such property is very valuable for a computer-aided system that enables improvements in both diagnosis and treatment. There is an increasing interest for decision support in the medical domain. Early approaches in decision support in the medical domain never got full clinical acceptance due to their less intuitive reasoning and explanation capability [1]. Computer–Aided System or Decision Support System (DSS) that can simulate expert human reasoning or serve as an assistant of a physician in the medical domain is increasingly important. In medical domain, diagnostics classification and treatment are the main task for a physician [16]. System development with such purpose is also a popular area in Artificial Intelligence (AI) research.

Today, Clinical Decision Support System (DSS) are developed to act multipurpose and are combined with more than one. AI method and technique [2], [12].

Decision support system(DSS) that bear more similarities with human reasoning have benefits and are often easily accepted by physicians in the medical domain. In most tropical countries, most of which are developing countries, medical personnel and facilities are not adequate for effective tackling of tropical diseases. In rural areas, medical attention is grossly inadequate.

Intelligent systems have become vital in growth and survival of health care sector. Recently much effort has been concentrated on developing intelligent system [3]. Medical knowledge is today expanding rapidly, making computer aided diagnostic system desirable. Such system can give a clinician a second opinion. Recent advances in Artificial Intelligence (AI) offer methods and techniques with potential of solving tasks previously difficult to solve with computer-based systems in medical domains. Research worldwide is focusing on the new applications in the medical field and particularly diagnosis [4]. Amongst the task considered in AI (control, monitoring, scheduling, diagnosis), the diagnosis is considered one of the most computer task and great efforts have been done in AI to solve this problem in different scenarios. Medical diagnosis is the identification of abnormal condition that afflicts a specific patient, based on manifested clinical data or lesions. If final diagnosis agrees with a disease that afflicts a patient, the diagnosis process is correct, otherwise, a misdiagnosis occurred [5].

Developments in computational techniques including clinical decision support systems, information processing, wireless communication and data mining hold new premises in Personal Health Systems. The medical knowledge is frequently updated and re-evaluated comprising new risk factors identification, new drugs and diagnostic tests, new evidences from clinical studies. The challenges faced today are to incorporate the most recent and evidence-based knowledge into Personal Health Systems and to transform collected information into valuable knowledge and intelligence to support the decision making process. Several expert systems tailored to specific diseases are nowadays available in clinical research, often covering the topics addressed by European priorities. Technology can play a key role to gain the continuity of care and a person-centric model, focusing on a knowledge-based approach integrating past and current data of each patient together with statistical evidences. In currently applied care practices, the emergence of clinical symptoms allows a disease to be discovered. Only then, a diagnosis is obtained and a treatment is provided. Currently, different healthcare practice models are used [6].

Intelligent analysis of heterogeneous data and information sources for efficient decision support presents an interesting yet challenging task in clinical environments. This is particularly the case in stress medicine where digital patient records are becoming
Stressors are also individual. Some people are not stressed by making a presentation before a large group of people, while others experience paralyzing stress. Many people experience varying degrees of stress before an examination; some are always in a state of stress, irrespective of their level of preparation, others never seem to experience stress on such occasions. Although stress is a psychological reaction, it strongly affects us physiologically as well. The heart rate, blood pressure, hormone secretion, digestive system, breathing, muscular tension and bodily movements, to name just a few functions, are all affected by stress. Stress seems to affect the totality of our biological system; almost nothing physiological stays normal when we are in a state of stress [9].

Medical investigations have identified that finger temperature (FT) has a strong correlation with stress status for most people. Diagnosing individual stress condition based on finger temperature measurements is not easy and understanding large variations of measurements from diverse patients requires knowledge and experience and, without adequate support, erroneous judgment could be made by a less experienced staff. It is also time-consuming and tedious task for humans to diagnose stress-related disorders from a semi or even unstructured text format [7]. Stress is a normal part of life.

In small quantities, stress is good; it can motivate you and help you become more productive. However, too much stress, or a strong response to stress can be harmful. How we perceive a stress provoking event and how we react to it determines its impact on our health. We may be motivated and invigorated by the events in our lives, or we may see some as “stressful” and respond in a manner that may have a negative effect on our physical, mental, and social well-being. If we always respond in a negative way, our health and happiness may suffer. By understanding ourselves and our reaction to stress-provoking situations, we can learn to handle stress more effectively [11].

2. REVIEW OF RELATED LITERATURE

In the study of Mobyen in [1], A Cased-Based Multi-Modal Clinical System for Stress Management was developed. The motivation for this research include: diagnosis and treatment of stress is an example of a complex application domain, it is well known that an increased stress level can lead to serious health problems.

The rise (increases) and fall (decreases) of the finger temperature (FT) can help to diagnosis stress-related dysfunctions and without having adequate support, erroneous judgment could be made by a less experience staff. This research work proposes a Multi-Modal and multipurpose oriented clinical decision support system for the stress management. It is based on the finger temperature (FT) sensor data as well as contextual information i.e. human perception and feelings in textual format. The system applies CBR as a core technique to facilitate experience reuse and decision explanation by
CDS was implemented by means of a fuzzy-logic rule based classification scheme was introduced into the CBR system.

In [7], Case-Based Reasoning for Diagnosis of Stress using Enhanced Cosine and Fuzzy Similarity was presented by Mobyen et al. The research emphasized that diagnosis individual stress condition based on finger temperature measurements is not easy and understanding large variations of measurements from diverse patients requires knowledge and expertise and, without adequate support, erroneous judgment could be made by a less experienced member of staff. It is also time-consuming and tedious task for humans to diagnose stress-related disorders from a semi or even unstructured text format. The system provided a case-based reasoning system using Fuzzy and Cosine similarity to create decision support for clinicians with emphasis on hybridization of textual data with time series measurements as case representation. Evaluation of the systems performance was carried out.

A Hybrid Case-Based System in Clinical Diagnosis and Treatment was presented in [12]. In this work, a Hybrid Clinical DSS for stress diagnosis and treatment based on a novel combination of several techniques from Artificial Intelligence. CBR was used as the core Technique and by using textual information retrieval (IR) with ontology the system is able to handle patient’s contextual information such as life style and habits better. Fuzzy Rule-Based classification scheme handle the so called boot strap problem where only a limited number of cases are available in the beginning of the system. Evaluation of the systems performance was also carried out.

In the study carried out by Gennaro et al [6], dedicated algorithms were implemented in the PDA to filter, process and extract relevant features from the three lead ECG and three-axis accelerometer signals. The CDSS was implemented by means of a fuzzy-logic rule based algorithm. The CDSS receives as input the features module and provides as output the level of stress (SL).

The fuzzy-logic rule based algorithm consists of three steps: fuzzification, inference and defuzzification. The performance of the system was also evaluated.

Medical researchers have shown that stress can intervene in regulation of different organ system activity (for example variation of blood pressure and heart rate, platelet activation, immune and inflammatory response under mental stress). The study of Vikas and Mahendra [8], presented A mental stress Assessment of ECG signal using Statistical Analysis of Bio-orthogonal wavelet coefficients:- The methodology involved extraction of ECG (electrocardiogram) using two leads method (including H/W and S/W- embedded system), decomposition of ECG using (bio-orthogonal) bior 3.9 wavelet family, extraction of SD, mean, power, entropy, energy, covariance and homogeneity. Analysis of the extracted features to measure stress level where stress level = f (SD, mean, power, entropy, energy, and covariance). A backward propagation Neural Network was trained using the features as input in order to classify the stress level.

Armidcha and Awani in [13], presented Human-Computer Interaction of Design Rules and Usability elements in Expert System for personality Based Stress Management. ESPBSM was developed with a goal to mimic the role played by a counselor or psychologist of stress expert to provide a virtual consultancy, act like a virtue psychologist. The system embodies three main functions consisting of diagnosis, remedies and education.

The developed system used combination of rule based techniques to determine the best solution of recommendation to manage stress.

A Stress Detection System Based on Physiological Signal and Fuzzy Logic was developed in [14]. Only two signal-GRS (Skin conductance) and HR. Training, validation and testing of the extracted features for the system’s development was based on Fuzzy Logic. The performance of the system was measured.

It was observed from the reviewed works that many people who have stress do not even know that they are already stressed which result in deterioration to many other diseases or illness that are difficult to manage such as paralysis, stroke, mental illness, heart failure, hypertension and sudden death. The shortages of medical personnel, hospitals and equipment were also evident as major challenges in health sector. Most available computer assisted diagnostic systems on stress management are biomedical signal device dependents which is a major setback. In this work, we propose a simple system that can carry out stress diagnosis based on symptoms checker and if rule based.

3. METHODOLOGY

3.1 Description of Dataset

Visits were made to reputable hospitals in Ado-Ekiti metropolis of Ekiti State, Nigeria. Medical experts were interviewed on diagnosis of stress which gave insight on how the diagnosis could be carried out in the absence of biomedical signal devices such as ECG and EMG. A lot of literatures on stress diagnosis were also taken into consideration. Figure 1 below shows the conceptual diagram of the system’s development.
It was noted that there are four main classifications of stress as also reported in [15] and [11] - cognitive/mental, physical, emotional and behavioral. One of the major problems of diagnosing stress is the associated multiple symptoms which makes classification difficult. Some of the symptoms associated with the different categories of stress are given below:

**Physical:** Chills, Difficulty breathing, Dizziness, Elevated blood pressure, Fainting, Fatigue, Grinding Teeth, Headaches, Muscle Tremors, Nausea, Pain, Profuse Sweating, Rapid heart rate, Twitches, Weakness.

**Cognitive / Mental:** Blaming someone, Change in alertness, Confusion, Hyper-vigilance, Increased / decreased awareness of surroundings, Intrusive images, Memory problems, Nightmares, Poor abstract thinking, Poor attention, Poor concentration, Poor decision-making, Poor problem solving.

**Emotional:** Agitation, Anxiety, Apprehension, Denial, Depression, Emotional chock, Fear, Feeling overwhelmed, Grief, Guilt, Inappropriate emotional response, Irritability, Loss of emotional control.

**Behavioral:** Increased alcohol consumption, Antisocial act, Change in activity, Change in communication, Change in sexual functioning, Change in speech pattern, Emotional outbursts, Inability to rest, Change in appetite, Pacing, Startle reflex intensified, Suspiciousness, Social withdrawal.

### 3.2 Experimental Set Up and Result

As evident by consulted medical experts and also Klinic Community Health Centre in [11], the more signs and symptoms you notice in yourself the closer you might be to feeling stress overload. Diagnosis was focused on the four different categories of stress. Structured questions on the associated symptoms of each category of stress were directed to the patients. The data collected were carefully examined by the medical expert and this forms the basis for decision making. There is only one decision attribute which takes one of the values: SEVERE, HIGH, LOW and NOT STRESSED. The available symptoms of each patient determine the level of the stress. A sample of the questions directed to the patients/users is presented in Table 1 below, where each of the symptoms can take a value from OFTEN, SOMETIMES and RARELY. These values show the degree of severity of the symptom.

**Table 1: Mental Stress Diagnosis Section**

<table>
<thead>
<tr>
<th>Questions</th>
<th>OFTEN</th>
<th>SOMETIMES</th>
<th>RARELY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blaming someone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in alertness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hyper-vigilance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased/decreased awareness of surroundings</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Intrusive images</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nightmares</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Poor abstract thinking</td>
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<td></td>
<td></td>
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<tr>
<td>Poor attention</td>
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<td></td>
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<tr>
<td>Poor concentration</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Poor decision-making</td>
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<td></td>
<td></td>
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<tr>
<td>Poor problem solving</td>
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</tbody>
</table>

In Consultation with medical experts, the percentage of OFTEN, SOMETIMES and RARELY generated from the symptoms were used to generate rules for the diagnosis. This is presented in Table 1 below. It is to be noted that each of the parameters- OFTEN, SOMETIMES and RARELY has a Counter with initial value of Zero (0). For instance when OFTEN is selected the counter (i.e. Ocount) assigned to it is increased by one (1). The counter for OFTEN is denoted Ocount, SOMETIMES is denoted Scount, and RARELY is denoted Rcount. The system does the comparison of the numbers of OFTEN, SOMETIMES and RARELY and
uses this to carry out the diagnosis. The predefined rules for the diagnosis are presented in Table 2 below:

<table>
<thead>
<tr>
<th>Rule Number</th>
<th>Condition</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Ocount &gt; Scount) AND (Ocount &gt; Rcount)</td>
<td>STRESS = 4</td>
</tr>
<tr>
<td>2</td>
<td>(Scount &gt; Ocount) AND (Scount &gt; Rcount) AND (Rcount &gt;=3)</td>
<td>STRESS = 3</td>
</tr>
<tr>
<td>3</td>
<td>(Scount &gt; Ocount) AND (Scount &gt; Rcount) AND (Rcount &lt;=2)</td>
<td>STRESS = 2</td>
</tr>
<tr>
<td>4</td>
<td>(Rcount &gt; Ocount) AND (Rcount &gt; Scount)</td>
<td>STRESS = 1</td>
</tr>
</tbody>
</table>

The system has four (4) different sections to carry out the diagnosis: Mental/Cognitive Stress Diagnosis Section, Physical Stress Diagnosis Section, Behavioural Stress Diagnosis Section and Emotional Stress Diagnosis Section. There is only one decision attribute which displays one of the values: Stress = 4, Stress = 3, Stress = 2, Stress = 1 at a time. Since it is easier to work around with numbers value 4 under decision means Stress diagnosed is SEVERE, value 2 means Stress diagnosed is HIGH, value 3 means Stress diagnosed is LOW and value 1 means Stress is NOT SUSPECTED.

3.3 Implementation and Discussion of Results

In order to build confidence for any Computer Based Diagnosis system, it is desirable to evaluate the performance of the system because healthcare management systems deal with human lives directly, hence caution must be taken [2]. The rules were implemented in visual studio 2010 environment, using Visual Basic 2010 which served as the front end; MySQL was used as back end. The rules generated in consultation with Medical Experts served as the engine room of the diagnosis system. A new user interacts with the system by registering with his intending username and password, while existing user just login to the system by supplying appropriate username and password. If these are correct, the next interface-diagnosis section selection interface is displayed. This interface affords the user to select the diagnosis section of interest – Mental Stress Diagnosis Section, Emotional Stress Diagnosis Section, Behavioural Diagnosis Section or Physical Stress Diagnosis Section.

After the user selects, the diagnosis section of choice, the interface of the selected section is displayed. Figure 2 below shows the snapshot of the Mental Stress Diagnosis Section of the System.

Figure 2: Snap shot of the Mental Stress diagnosis Interface (Mental Stress Diagnosis Section)

After careful answers to the questions, submission is made to the system by clicking ‘Submit’ button, after which the result of the diagnosis is displayed.

In case Stress is detected, useful advice is displayed according to the level of severity. Every part of the system was tested to make sure that the system gives optimum satisfaction. The system’s performance was tested with real life data and the results were similar to the results of those diagnosed by medical experts.

4. CONCLUSION

It was observed that stress is a silent killer, destroying human dreams and killing people unaware. It is evident in this work that the world is in shortage of medical personnel which has made computer based diagnostic systems desirable. Most of the available systems on managing stress today relied heavily on the use of biomedical signal devices such as ECG(Electrocardiogram) and EMG (Electromyography) which are expensive, difficult to handle and uncommon.

These among other reasons make diagnosis of stress difficult. A new simple system which can manage stress effectively without the use of these expensive
devices has been proposed in this work. It is hopeful that this system will reduce the number of patients consulting hospitals on stress cases and save more lives if effectively put into use. However this system could be improved by making it a mobile application based which will absolutely increase its accessibility.

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