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IoT-TPMS: An innovation development of triangular patient monitoring system using medical internet of things

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***Abstract*---**In general, the number of diseases is increasing in the current era. There is also a growing fear among the patients about the nature of the growing number of new diseases and their consequences. Thus the patients are interested in getting treatment from healthcares for minor physical problems. But factors such as lack of space in healthcares and lack of time for doctors make patients uncomfortable. Sometimes doctors recommend that patients come to the healthcare only for emergency treatment. In this paper, a triangular method is proposed which takes into account the needs of the patients, calculates the time management of the doctors and analyzes the facilities available in the healthcares. Designed with the help of medical IoT devices, efficient sensors fitted to patients' bodies monitor their physical condition. Furthermore based on this sensor

information the doctor can provide the patient with the necessary instructions from where they were. These sensors send information directly to the healthcare when further emergency treatment is needed. Thus healthcares can make the necessary arrangements to provide the necessary treatments to the patient immediately. A special feature of the proposed system is that it solves three complex problems like physician time, healthcare accommodation, and patient care.

***Keywords*---**diseases, treatment, healthcare, emergency treatment, triangular method, medical IoT, sensor.

1. Introduction

It is impossible to imagine life without stress. To an extent, the presence of stress may be necessary for normal development [1]. However, too much pressure can trigger mental illness and increase mental distress. Although the specific causes are unknown, it is clear that stress and mental illness are strongly linked [2-3]. Stress is a cause of many disorders and anxiety. It is caused by complex social, familial and biological factors such as sexual harassment, physical harassment, psychological influences, family violence, assaults and disorders in children or adolescents and mental illness [4]. Although the cumulative effect of such experiences over time makes mental illness more likely, a single major trauma can cause mental illness. Tolerance to this varies from person to person. Tolerance varies due to genetic predispositions, characteristics, thoughts, and other experiences [5]. Stress can be considered any physiological, chemical or psychological factors that cause physical or mental tension that can cause diseases [6]. Trauma, infection, poisoning, ill health, injuries etc. can be mentioned as physiological and chemical factors. There are many psychological factors. Although many compare stress to mental illness, scientists and doctors refer to it as the potential to cause impairments in physical function and balance [7-8]. When they are stressed by what is happening around them, certain chemicals are secreted into the blood in response. These chemicals give them more energy and strength. Low levels of stress or anxiety are sometimes helpful [9]. For example, due to the stress of executing a project, we focus better and do the work with more energy. There are two types of stress: eustress (positive stress) and distress (negative stress). Negative effects occur when stress is high and not properly managed [10].

When it comes to depression, don't expect sufferers to be crawling with sadness or ready to cry at any moment. Depression is a lack of involvement in important life events [11]. People under stress tend to eat more or less; will sleep; they will leave the circle; they avoid friendship and prefer solitude; They are disinterested in routine activities [12]. They have little or no energy to perform an action [13]. They will be in a kind of confused mood with unusual forgetfulness. They are in a state of extreme anger, sadness and fear and are in a state of emotional outbursts. They also have the intention of harming themselves or others [14]. Stress is associated with health problems such as chronic illnesses, anxiety, obsessive-compulsive disorder, and depression. It usually lasts two years or more.

The limbic system in the brain controls our bodily functions and mood [15]. It is this system that balances our mood after the vicissitudes of life. In the nervous limbic system, two chemicals, serotonin and noradrenaline, do the work of exchanging information. Stressed people have less secretion of these chemicals [16]. In this sense, depression is not a mental illness; It is a disease of the body. Fungal-minded people easily break down and fall into depression when under stress [17]. Strong-minded people redouble their efforts and try to get out of stress without collapsing until the limbic system collapses completely [18]. The medical world today accepts that stress can be caused by financial hardship, personal losses, relationship breakdowns, prolonged illness, excruciating pain, substance abuse, past traumas, and shame [19]. Also, extreme stress or some kind of illness can make our body's immune system work more than needed. Medical science says that this causes inflammation in the brain and stress due to it [20].

These drugs can cause side effects such as dry tongue, constipation, loss of appetite, excessive hunger, mild dizziness, stomach irritation, delayed menstruation, excessive/deficient menstrual bleeding [21-23]. Also, in the early stages of a serious mental illness, counseling may not be helpful. But their families need advice on how to deal with them. It says that counseling is offered to patients only after the symptoms of depression are under control [24]. Counseling is very important for mild depression. Pills are needed in the early stages to reduce both the resulting insomnia and anxiety. Once sleep returns to normal, the pills can be stopped. Conception in transcendental sleep remedies can provide good results for mild depression. [25-27]

2. Literature Review

Dheeraj, N. G et al. [6] discussed the short-term stressors, such as 'fight' or 'flight'-type effects, are considered short-term stressors. These are the immediate effects of certain chemicals in the brain and the brain when exposed to hazards or stressors.

Ahmed, A et al. [11] discussed the factors that persist or persist after the factors that precipitated the fight or flight have ended are considered long-term effects. A constant stressful job, relationship problems, loneliness, financial worries are some of these.

Yempally, S et al. [15] discussed to manage stress starts with knowing the factors that cause it. It is not an easy task as it is said. To find out the real factors, examine your character, habits and frequent excuses. Unless you are responsible for your affairs, you cannot control stress.

Saravanan, S et al. [17] discussed with logs, you can identify common stressors and avoid them. If a person feels that he/she is suffering from depression, it should be recorded. By registering in this way, a sense of generality can eventually be felt. Think about how you deal with stress right now. Your records may help you with this. The coping strategies of healthy or just adding help to avoid the stress. Many people, through their negative coping mechanisms, increase stress.

Johri, A et al.[19] expressed there are healthy ways to deal with stress, but they are only possible through change. We need to change something about the stressful situation or its consequences. Think deeply about it and consult with others. Identify factors or people and adopt ways to reduce or eliminate them

Jaishankar, B et al. [20] discussed the disease continues to increase as many patients do not recover even after treatment for depression. Increasing stress and isolation are the main reasons for the rise of this disease. People aged 60-74 are more likely to suffer from depression than other age groups. The disease is increasing due to the increasing number of elderly people in the world

Odusami, M et al.[28] discussed new antihypertensive drug has been discovered in the last 25 years. Thus, psychiatrists are forced to think beyond drugs to treat depression. Research results with ketamine and psilocybin are promising for the future. Recent scientific discoveries about genetic variants give hope for a new generation of treatments for depression

Hossain, M. J et al [29] expressed the research is ongoing on the link between low immunity, depression, and inflammation in the brain. Although this research is controversial, it has the potential to lead to new treatments. Many countries today have realized the need to train psychologists as an alternative to drugs.

3. Problem Formation

A mental health counselor talks to a person in a scientific approach and patiently listens to the problems from their point of view. Then he will analyze it psychologically and give proper guidance and advice. Instead of advising the solution to their problem, the victim chooses the way. By making the right change in one's thinking, feeling and behavior, he paves the way for better progress in one's life. Strategies such as life skills, healthy life style training and psychoeducation to understand the workings of the mind are also used for this purpose. Mental problems usually caused by psychological reasons such as anxiety disorders, phobias, depression and stress, problems in husband and wife relationships, teenage depression, divorce. Counseling and psychotherapy by psychologists/professionally trained counselors are sufficient for many problems such as death/separation of a loved one, lack of focus in studies. Mental illnesses with biological and genetic causes also require medication prescribed by a psychiatrist

- Life stress: When a person fears that something will physically attack him, the body immediately gives maximum energy to protect him from the situation or escape.
- Internal Stress: Due to this people create pressure on themselves. It occurs when we develop worries about something we cannot control. Some people get used to this way of life. They like and accept more stressful situations.
- Environmental stress: Stress caused by factors such as noise, crowd, work or family stress. Stress levels can be reduced by knowing environmental factors that cause stress and avoiding them.
- Fatigue and overwork: This type of stress caused by the burden of long days will cause more physical damage. It is caused by doing too much or difficult work at home or school. It is also caused by not properly planning time for

rest and recreation. This is considered the most severe stress as many find it difficult to control.

A person's ability to withstand stress varies from person to person as it can be caused by one or more of the following factors. A person's stress tolerance may also vary with periods:

- Childhood experiences (may affect stress tolerance due to abuse)
- Processes in people (some may be more affected than others)
- Hereditary (such as delayed activity that is inherited, especially related to levels of the key brain chemical serotonin)
- Differences in immunity (decreased tolerance due to joint pain, rashes etc.)
- Lifestyle (poor diet and sedentary lifestyles)
- Duration of occurrence of stressors

The symptoms may seem normal to everyone. When they are excessive and persistent, affecting one's personal abilities and interfering with daily life, it is necessary to consult a psychologist. A person who adjusts himself according to the changing situation is considered to be sane. Those who have a weak mind and are unable to cope with life's problems without being able to change, often suffer from mental health problems. It does not mean that only those suffering from a severe mental disorder should seek psychiatric treatment. It is important to seek advice even when you are unable to cope with the problems in life and break down. Just like going to a doctor for a minor ailment like a fever, going to a mental health counselor for a mental problem. If everyone realizes this, it is a healthy change. The ability of our people will also increase manifold due to the good mental health brought about by this change shown in table 1.

Table 1: Stress identification dataset 1- Routine effects

S.No	Routine effects	Level	Score
1	Sleep disturbances	Normal	10
2	loss of appetite	Normal	10
3	Lack of attention, memory loss	Critical	50
4	Uncharacteristic mistakes, delays	Critical	50
5	High level Anger	Critical	50
6	Violent or anti-social activities	Medium	25
7	Psychological manifestations	Critical	50
8	Alcohol or other drug use	Medium	25
9	Impulsive actions	Critical	50

Stress identification dataset 2- Physical effects: Often manifested in relation to nerves, glands and immunity. Regardless of the cause of stress, the body exhibits similar symptoms. Some of them are listed below table 2:

Table 2: Stress identification dataset - Physical effects

S.No	Physical effects	Level	Score
1	Palpitations, increased heart rate	Critical	50
2	Increased, shallow breathing	Critical	50

3	Trembling	Critical	50
4	Cold or rooting	Normal	10
5	Wet brow area	Medium	25
6	tightening of abdominal muscles	Medium	25
7	Stomach disorders	Medium	25
8	Frequent urination	Medium	25
9	Hair loss	Normal	10

Stress identification dataset 3 - Psychological effects: Manifests in many ways when not treated properly. Unresolved psychological problems can affect mood and then physical condition shown in table 3.

Table 3: Stress identification dataset - Psychological effects

S.No	Psychological effects	Level	Score
1	Difficulty concentrating	Critical	50
2	Difficulty making decisions	Critical	50
3	Loss of confidence	Critical	50
4	Uncontrollable desires	Medium	25
5	Unnecessary worries, agitation	Medium	25
6	Extreme fear	Medium	25
7	Effects of fear	Critical	50
8	Frequent changes in personality	Medium	25

Stress identification dataset 4 - Functional effects: Certain types of stress affect hormones, neurotransmitters in the brain, other small amounts of chemicals, key activators, and physical activity. How the affected person acts is reflected in table 4:

Table 4: Stress identification dataset - Functional effects

S.No	Functional effects	Level	Score
1	Excessive smoking	Critical	50
2	Neurological impulses	Critical	50
3	Excessive alcohol or drug use	Critical	50
4	Habits like teeth grinding, hair pulling	Medium	25
5	Memory loss	Critical	25
6	Getting into an accident	Critical	25
7	Incitement to brutal acts of violence	Critical	50

Functional consequences are dangerous and can affect social and interpersonal relationships. The effects of loneliness, poverty, sadness, stress, and frustration caused by exclusion are not only lasting but also reduce immunity against viral attacks ranging from the common cold to AIDS.

4. Proposed Model

Diagnosing important physiological problems in patients is usually essential. The primary angle is to diagnose the disease that develops in them based on the changes in their physiology. Informing the doctor through IoT devices is the

second angle and finally giving information to the hospital as per the doctor's advice is the third angle. All these three tasks are effectively performed in the presently proposed method. A comprehensive understanding of mental illnesses is essential for planning treatment of mental illnesses shown in table 5. A person's stress level can be determined by measuring cortisol (cortisol) and DHEA (dehydroepiandrosterone), two chemicals secreted by the adrenal gland. A final assessment is made by adding up the number of Life Change Units that have occurred in the past year as measured by Life Change Units. For example, if there is death of husband or wife, 100 marks will be given for it.

- When the composite scores are 300+, diseases are likely to occur
- Composite score of 150-299 – up to 30% lower risk of developing the disease
- 150 composite score- Chances of getting sick are very low
-

Table 5: Disease Confirmation table

S.No	Score	Possible Disease	Result
1	200-225	Stomach diseases	Consult with doctor
2	275-300	Drug addiction	Consult with doctor
3	250-275	Asthma	Home care Medical Treatment suggestion
4	125-150	Fatigue	Home care Medical Treatment suggestion
5	100-125	Headache	Consult with doctor
6	175-200	Blood pressure	Home care Medical Treatment suggestion
7	225-250	Insomnia	Hospital Medical treatment suggestion
8	350-375	Digestive disorders	Hospital Medical treatment suggestion
9	300-325	Cardiovascular diseases	Hospital Medical treatment suggestion
10	75-100	Affected mood	Consult with doctor
11	325-350	Sexually Inability	Hospital Medical treatment suggestion
12	150-175	Skin diseases	Home care Medical Treatment suggestion

Analyzes of patients were performed and individual scores were assigned for each mental stress-related outcome. According to the sum of these, the extent of the disease is predicted for them. Based on this, they can report their problems to the doctor and in this way; An IoT devices are very helpful to the doctors in making medical suggestions to the patients and knowing the severity of their disease from their location. Thus the first angle test is executed successfully. The proposed model block diagram was shown in following fig 1.

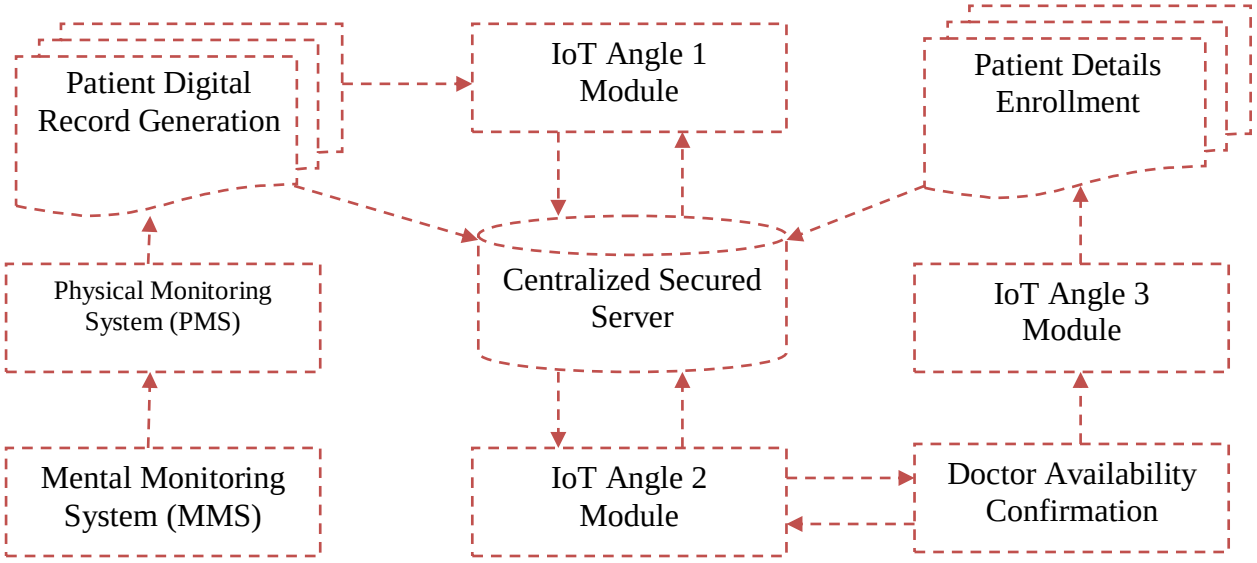

Fig 1: Proposed TMIoT System block diagram

Mental Monitoring System (MMS): The mental monitoringsystem is the type of monitoring system which is used to observe the different mental stress and emotions of the patient. Because of this observation the basic emotion level was identified. Then the observation values are added in the consolidation table.

Physical Monitoring System (PMS): The physical monitoring is the observation where the actions are performed due to the mental stress. These physical observations provide the effects of stress in the external manner. Based on these observations, the scores are entered into the consolidation table.

Patient Digital Record Generation: The patient digital record is the document which includes the patient disease details includes the general body check-up informations. Based on the physical and mental stress prediction these digital records were created and this information is transferred into the doctor.

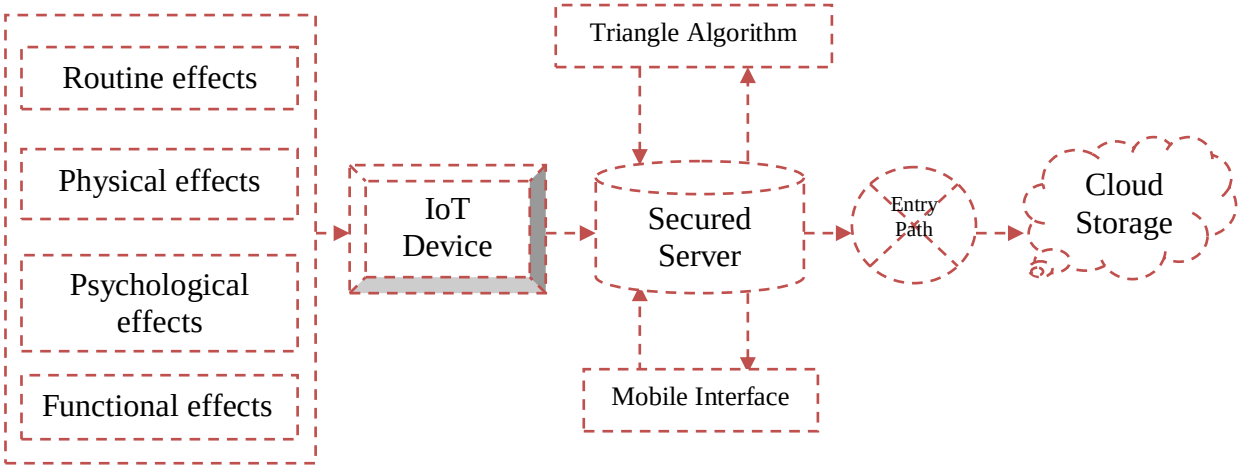

Fig 2: Proposed System TMIoT operational diagram

IoT Angle 1 - Patient disease identification: In this module all the emotional basis scores are consolidated and enroll the final consolidation table. Based on the table 5 scores, the disesases predictions are concluded and the predictions are finalized.

IoT Angle 2 – Disease detils transfer to the doctor: After finalized the disease, hen these details are stored in the centralized server. These informations need to transfer to the doctor. These transfer operations between the patient and doctor was performed by the IoT device. This is helpful here to transfer the patient disease information to the doctors as the digital pationt record format. Based on the report the doctor can suggest the patients to follow the treatment either in home oe in hospital.

IoT Angle 3 – Hospital Confirmation: After the doctor confirmation, this information was stored in centralized secured server and forwared to the hospital. The hospitals are has the access to view the patient information after completed the doctor suggestions. If the emergancy confirmation getting from the doctor, then the hospital assign the treatment details to the patient and send the alert to the patients.

Triangular Patient Monitoring Systems	
Step 1	Enter the physical monitoring details
Step 2	Enter the mental monitoring details
Step 3	Calculate the cut-off score
Step 4	If (cut-score = normal)
Step 5	Send the patient details to the doctors
Step 6	Confirm the consultation appointment
Step 7	Else If (cut-score = medium)
Step 8	Then assign the doctor to visit the patien home
Step 9	Send the doctor confirmation details to the patient
Step 10	Else (cut-off score is = critical)
Step 11	Send alert to the doctor regarding the critical information

Step 12	Send the emergancy details to the hospital
Step 13	If (emergancy confirmation accepted by the doctor)
Step 14	Then confirm the admission status of the patient
Step 15	Else (request the doctor for the confirmation)

Based on the given inputs, firstly the inputs related to the health of the patients are given. Then their mental health related data is entered. Based on this data the score is calculated according to the schedule events. The disease is diagnosed based on this score. IoT devices will help to send the information of this disease to the doctor and based on the information the doctors will give their decisions. According to these results, its intensity is calculated and can be analyzed based on its volume. If its results are declared as "Normal" it is recommended for doctors' results. Perhaps if the result is "Medium" the doctor is recommended to visit the patient's home. Perhaps when the result is "Critical", the patient is advised to go to the doctor immediately on the doctor's recommendation.

5. Results and Discussion

The proposed IoT Triangular Patient Monitoring SYstem (IoT-TPMS) was compared with the existing IoT Patient Monitoring System (IoT-PMS), Real-Time Patient Monitoring System (RT-PMS), Patient Monitoring System using Internet of Things (PMS-IoT), and Cloud-Based Remote Patient Monitoring System (CBR-PMS)

5.1. Emergency Recognition Rate (ERR):

The emergancy recognition rate is the computational results while the immediate execution of orders related to immediate notification of patient's emergency conditions to the physician and transfer of information from the physician to the hospital. Its main function is considered to be to conduct aggregate operations faster.

$$E_{RR} = \sum_{r=1}^{k} L_i \quad (1)$$

Where,

E_{RR} = Emergancy recognition rate
r = initial instruction rate
L_i = Recognition index

The follwing table 6 was illustrating the comparion of the emergancy recognition rate of the proposed and existing models.

Table 6: Comparion of the emergancy recognition rate

No of Instructions	IoT-PMS	RT-PMS	PMS-IoT	CBR-PMS	IoT-TPMS
100	55.09	57.36	70.69	72.10	93.52
200	54.76	55.86	70.10	70.23	92.51
300	53.42	54.75	69.12	69.40	92.35
400	52.28	54.37	67.91	68.49	91.39
500	51.23	53.36	66.77	67.57	91.82
600	50.52	52.43	65.66	66.24	90.62
700	49.22	51.43	64.96	65.37	90.47

5.2. Triangular Accuracy (T_A)

The accuracy is the term refers to the ratio between the sum of the original positive predictions of the detected instructions and original negative prediction instructions and total instructions deteced by the IoT devices of the three different angles of the proposed model.

$$T_A = \frac{(A_{OP1} + A_{OP2} + A_{OP3}) + (A_{ON1} + A_{ON2} + A_{ON3})}{\sum A_d} \quad (2)$$

The follwing table 7 was illustrating the comparion of the triangular accuracy of the proposed and existing models.

Table 7: Comparion of the triangular accuracy

No of Instructions	IoT-PMS	RT-PMS	PMS-IoT	CBR-PMS	IoT-TPMS
100	57.39	59.66	67.29	69.36	94.43
200	57.06	58.16	66.70	67.49	93.39
300	55.72	57.05	65.72	66.66	93.26
400	54.58	56.67	64.51	65.75	92.30
500	53.53	55.66	63.37	64.83	92.73
600	52.82	54.73	62.26	63.50	91.49
700	51.52	53.73	61.56	62.63	91.38

5.3. Triangular Precision (T_P)

The precision is the term refers to the ratio between the original positive predictions of the detected instructions and the sum of original positive prediction instructions and false positive prediction instructions deteced by the IoT devices of the three different angles of the proposed model.

$$T_P = \frac{(P_{OP1} + P_{OP2} + P_{OP3})}{(P_{OP1} + P_{OP2} + P_{OP3}) + (P_{FP1} + P_{FP2} + P_{FP3})} \quad (3)$$

The follwing table 8 was illustrating the comparion of the triangular precision of the proposed and existing models.

Table 8: Comparion of the triangular precision

No of Instructions	IoT-PMS	RT-PMS	PMS-IoT	CBR-PMS	IoT-TPMS
100	56.13	67.40	74.85	77.80	93.69
200	54.50	65.66	73.27	76.38	92.40
300	54.02	63.32	71.07	75.12	91.39
400	52.73	62.51	69.44	73.13	90.50
500	50.62	60.22	68.30	70.66	90.13
600	49.13	58.29	66.10	69.22	88.49
700	47.32	56.56	64.95	67.50	88.12

5.4. Triangular Recall (T_R)

The precision is the term refers to the ratio between the original positive predictions of the detected instructions and the sum of original positive prediction instructions and false negative prediction instructions deteced by the IoT devices of the three different angles of the proposed model.

$$T_R = \frac{(R_{OP1} + R_{OP2} + R_{OP3})}{(R_{OP1} + R_{OP2} + R_{OP3}) + (R_{FN1} + R_{FN2} + R_{FN3})} \quad (4)$$

The follwing table 9 was illustrating the comparion of the triangular precision of the proposed and existing models.

Table 9: Comparion of the triangular recall

No of Instructions	IoT-PMS	RT-PMS	PMS-IoT	CBR-PMS	IoT-TPMS
100	66.02	63.30	74.69	76.79	93.69
200	64.53	61.33	72.27	74.59	93.70
300	63.73	60.20	71.86	73.79	92.50
400	61.40	59.01	70.26	73.12	92.02
500	60.39	58.62	67.94	71.69	90.59
600	59.75	57.10	66.69	70.60	89.43
700	59.09	56.86	63.96	70.12	88.66

5.5. Triangular F1-Score (T_F)

The precision is the term refers to the ratio between the sum of total precision and recall instructions deteced by the IoT devices of the three different angles of the proposed model.

$$T_F = \frac{2 * T_P * T_R}{T_P + T_R} \quad (5)$$

The follwing table 10 was illustrating the comparion of the triangular f1-score of the proposed and existing models.

Table 10: Comparion of the triangular f1-score

No of Instructions	IoT-PMS	RT-PMS	PMS-IoT	CBR-PMS	IoT-TPMS
100	57.51	66.93	77.20	80.99	90.53
200	57.62	66.91	77.37	81.26	91.03
300	57.64	66.03	76.64	80.96	90.91
400	54.54	63.20	73.30	77.45	87.68
500	53.34	61.88	72.57	76.13	87.30
600	52.73	61.05	71.68	75.59	86.73
700	52.32	60.65	71.60	75.29	87.03

6. Conclusion

The Psychiatrists refer to stress caused by chemical depletion of the body as severe stress and stress caused by life events as moderate stress. There are two

types of anti-depressants for severe depression. A drug that controls the agitation of the patient and calms him down was used to relief the stress. The second type of drug relieves fatigue and restlessness and increases vitality. If there are more suicidal thoughts or attempts, then patients should be hospitalized and monitored. The doctor can decide how long to take the medicine. In a saturation point the proposed model achieved, 91.39% of emergancy recognition rate, 92.30% of triangular accuracy, 90.50% of the triangular precision, 92.02% of the triangular recall and 87.68% of triangular f1-score. The major advantage is the emergancy recovary because based opn the emergancy the doctor advices the patients to admit the hospital and this information was transferred to the hospital and the patient. So the emergancy rescue of the patient was handled very effective manner.

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