



Application of Machine Learning in Diagnosis and Treatment of Fibromyalgia

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Abstract

Fibromyalgia is a disorder causes chronic pain throughout the body with general fatigue, sleeping disorder and Cognitive difficulties as most common symptoms. ML and AI the potential glimmers for future presumed to have the ability to process complex datasets outside the sphere of human capabilities. Later transforming the data analysis into clinical insight that assists doctor's planning and leading to improved results, better diagnosis, cost-effective care, and ultimately better treatment.

Here we try to provide a Machine Learning base application using most effective logarithms and image processing classifiers, better coordination between latest trending technologies and healthcare leverage the field of Rheumatology.

Keywords: Fibromyalgia; Rheumatology; Machine learning; Artificial intelligence

Introduction

Fibromyalgia is one of the most common syndromes in middle and old aged population. Nearly 2% of the population suffers from fibromyalgia in USA i.e. 4 million people. It has been observed that majority of the patients diagnosed with fibromyalgia are women. Diagnosis of fibromyalgia is very difficult because of the fact that no diagnostic test has been developed that can indicate the factors of this disease. So, most of the time the patients are misdiagnosed with other relatable chronic pain diseases such as rheumatoid arthritis, migraine and ...etc [1].

So, doctors use the method of elimination, by eliminating all possible diseases which shows similar clinical symptoms. Many times, patients consult multiple doctors, multiple departments and also sometimes had been received medication for certain different diseases. Similar to complex diagnosis, the treatment of fibromyalgia also difficult [2].

There has been 3 FDA approved drug that helps in reducing the pain but has very low success rate. Along with medication other things like yoga, meditation, and physiotherapy have shown significant results.

Fibromyalgia causes and internal functioning

Fibromyalgia is one of the most misunderstood syndromes because it is not exactly a disease, it's a syndrome. With no laboratory findings specifically indicating the probability of this disease, the whole world is divided into groups for its existence and non-existence. Some experts also debate this over proper categorizing it under Department of Rheumatology or Psychiatry, as it deals with brain and behavior issues [3].

It is widely regarded that fibromyalgia is caused by position displacement of hypothalamus. Hypothalamus is small region inside the brain which controls sleep, hormonal function, temperature, autonomic function (B/P, pulse, sweats, bowel function.... etc). Patients always feel fatigue and despite of having a good sleep, they always feel tired and lazy [4].

Hypothalamus increases the sensitivity in the person, he/she finds difficult to do things that he/she was easily able to do before like waking, writing, stairs climbing, running, lifting... etc. Patients also find difficulty in memory retention has mood issues and slowly loses interest in everything [5].

Causes of Fibromyalgia is also a point of debate, it is categorized into 2 types:

Sudden onset:

- Viral Fever
- Parasitic or Antibiotic Infection

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- Trauma
- Injury
- Pregnancy

Gradual onset:

- Hormonal or nutritional deficiencies
- Yeast/Candida infection
- Auto-immune diseases
- Sleep disorder
- Severe stress

Clinical symptoms

Muscle and joint pain with multiple tender points: The most common symptom for fibromyalgia is pain in muscles and joint. The pain has to be at least 3 months old and it may or may not have specific tender points.

Exercise intolerance pain: This type of pain is experienced by the body with the person does some activity. Usually the patients feel relaxed with they are resting, but as soon as they start doing some work the pain increases and the pain slowly decreases when they are subject to rest.

Allergies: Uncommonly some the patients develop allergies from certain type of food like dairy products, oily products... etc.

Body stiffness: Patients experience stiffness of the whole body or certain parts of the body like arms or legs when they wake up at morning. Usually this symptom is misunderstood as rheumatoid arthritis.

Brain fog (Inability to concentrate): One of the main functions of hypothalamus is memory retention, because of low memory retention power and constant headache; patients usually are unable to concentrate.

Fatigue: Patients despite of having a good sleep, they always feel tired and lazy.

Weight gain: Because of continuously resting for a long period, getting a good diet and medicine (with weight gaining as side-effect).

Frequent infection: With low immunity power patients tends to get infection frequently.

Anxiety or Depression: Anxiety & depression are both causes and symptoms for fibromyalgia. Person whose life has been affected and can't get back to normal life tends to show anxiety and depression.

Headaches: Usually patients have constant headache but the intensity of headache varies.

Sleeping problems: Patients doesn't feel well- rested after a night's sleep and experiences daytime tiredness or sleepiness.

Diagnosis and imaging test

Unfortunately, there hasn't been any lab investigation or imaging test that can arrive at the conclusion of confirming Fibromyalgia. So, the only method that is widely accepted is by excluding all possible diseases with similar symptoms like musculoskeletal pain [6].

List of disease with symptoms:

- Rheumatoid Arthritis

- Sjogren's syndrome
- Polymyalgia rheumatica
- Multiple sclerosis
- Chronic fatigue syndrome
- Vasculitides
- Hypothyroidism
- Lupus
- Osteoarthritis
- Depression
- Genetic Diseases

These all diseases have specified symptoms and lab investigation that accurately confirms the diseases. So, there is a set protocol to approach this problem. Firstly, some basic test like CPK, CRP, ESR, ENA profile, RA factor, etc are carried out, if some of these factors are positive, they high leveled panel test are done like Thyroid panel, ANA profile, Myositis profile... etc. At last if symptoms and lab finding indicate a possibility of a disease, then imaging test like X-ray, MRI, CT scan are performed [7].

Detailed list of tests are:

A. Basic tests: CPK, CRP, CBC, RA Factor, ESR, Anti-CCP, HbsAg, Vit A, B12, D3, LFT/RFT

B. Disease specified tests: ENA profile, ANA profile, Thyroid profile, Myositis profile, Muscle Biopsy, LDH, Lipid profile, Urine C/S, Genetics Testing

C. Imaging tests: X-ray (parts specific), CE-CT (chest), CT scan, MRI (parts specific), EMG

After going through all these phases, the diseases don't fall through any of the specified diseases then the probability of fibromyalgia is highly probable, with pain duration more than 3 months. In this case the Rheumatologist might consider the case to be a fibromyalgia and start treating it accordingly.

Treatment

Treatment of fibromyalgia requires holistic approach; it requires more contribution from patients and his families. This disease can't be treated by surgical operation and medication alone doesn't show as significant result [8].

The management of Fibromyalgia involves the followings:

Educating the patient: Educating the patient is one of the most important steps for Fibromyalgia patients. It involves completely informing the patient and his family about the causes, symptoms, and roadmap to treatment.

By explaining the role of hypothalamus in the diseases in simpler terms may also improve his satisfaction and he might not blame herself. Also, it removes the doubt of any life-threatening diseases from the patient that might relieve him from stress.

Graded exercise: It would be difficult for the patient to start with heavy exercise and it might also affect his confidence. So, gradual increase in exercise is recommended.

Patients might start with alternate day morning walk and slowly increase the distance.

Other exercise like swimming, stairs climbing, lifting light weight objects... etc

Sleep: Sleep is one of the most important factors to improve health. Patient must take at least 8-9 hours of daily sleep most probably from 10 pm to 6 am.

Medicine: FDA has approved these drugs, which has shown significant results.

- Amitriptyline
- Duloxetine
- Pregabalin

Psychotherapist: Some of the patients has developed stress and anxiety over the time during fibromyalgia, consulting the psychotherapist might also help.

Physiotherapy: Patients with unbearable pain with exercise intolerance are suggested physiotherapy. 'Low and Slow' type is generally recommended.

Positivity: The most important thing for overcoming fibromyalgia is positive nature towards the life.

Patients must think that the disease has been diagnosed and it can be easily tackled.

Yoga and meditation: Yoga and meditation are also recommended as they help to attain peace and calm mind.

Results and recovery

Results completely depend on patient's effort; it might be long and difficult but it's the only way for the treatment. Duration of recovery time varies from 3 months to 2 years, but for some of the people some of the symptoms might last lifelong.

Methodology

We have personally obtained the dataset of patients with fibromyalgia by contacting various rheumatologist, private clinics, government hospital, researchers, and private hospitals; as there was do ready-made datasets available on internet with any society.

After physical collection of data, with the help of experts we have trained, validated and test of Machine Learning program with sample cases. We had applied two classification algorithms Support Vector Machines (SVM) and K-Nearest Neighbor (K-NN) with an accuracy of 96.77%.

Data selection

As there were no readymade datasets available of fibromyalgia patients, so we have to personally contact rheumatologist and other experts for collecting data. We got help from private clinics, government hospital, researchers, and private hospitals. We have randomly picked 100-100 cases of patients diagnosed with fibromyalgia and other related diseases (non-fibromyalgia) respectively.

We have tried to gather data of varying age groups, sex, profession, locality, and clinical history. Also, we have randomly picked 20 cases to be tested for calculation of accuracy. Tabulating the data was big problem, as different labs have different standards and publish result in different units. For this we had to convert all similar test into standardize unit. Symptoms were another big challenge for us, as fibromyalgia patient may have just one to variety of symptoms.

Training, validation and testing

The dataset is divided into training, validation and testing. The training dataset is use to construct a Machine Learning model that will satisfy all similar condition. The validation datasets give an unbiased assessment of the Machine Learning model constructed by the training dataset. The testing dataset finally gives the overall feasibility of the model developed with the help of training dataset and validation dataset.

As we have limited dataset, so we will be using multiple fields for ML model. Also, as we are using this in medical field application, so we have to ensure the high working feasibility of the ML model.

Algorithm selection

We will be using two classification algorithms Support Vector Machines (SVM) and K-Nearest Neighbor (K-NN). Support Vector Machines (SVM) classification algorithm is one of the most suited for pattern recognition-based application. It is more specifically for problems with more fields and distinctive features. Support Vector Machines (SVM) is classified as supervised Machine Learning Algorithm.

Another most suited algorithm is K-Nearest Neighbor (K- NN), it is also supervised Machine Learning Algorithm. It is useful for both classification and regression-based problems. K-Nearest Neighbor (K-NN) is based on different technique; it uses closest training point than considering field parameter. In our ML based model, we employ both of the algorithms and based on the case we chose the one with better accuracy.

Illustration through Example

Patients on the basis of test conducted and consulted expert can be categorized into 3 types:

Type I: Haven't consulted the doctor and on the basis of self-examining the symptoms is using our Machine Learning Program.

Type II: Consulted the doctor and have conducted few tests but haven't been diagnosed with any diseases.

Type III: Consulted the doctor and have conducted all necessary tests and diagnosed with fibromyalgia.

We have developed a website in which with experts help patients can fill all necessary details. After filling all necessary details our ML programmed model will generate OPD consultation slip as following:

Type I: Based on the symptoms, our ML program will advise to conduct few tests and won't prescribe and medicine.

Type II: Based on the test conducted if the ML program finds any possibility of a diseases then it fills advice to consult the specialized doctor of that department and is, he is not sure then it will advise to conduct few more tests.

Type III: As the patient has already been diagnosed with Fibromyalgia, our ML program will reconfirm the syndrome and will advise the treatment plan for the patient.

There will be 6 web pages for patients to fill details with expert opinion:

1. Basic Details
2. Clinical Examination - Physical Examination, History
3. Laboratory Findings

Figure 1: Details.

Figure 3: Specific Examination.

Figure 2: General Examination.

Figure 4: Basic details.

4. Joint Fluid Analysis
5. Radiology
6. Tissue Biopsy

After filing all necessary details ML program will classify the case into I, II or III and advice accordingly (Figures 1-5).

Results and Discussions

We have successfully developed ML model which helps to

diagnosis and treatment of fibromyalgia. We have obtained at successful high accuracy by considering two classification algorithms Support Vector Machines (SVM) and K-Nearest Neighbor (K-NN). So, we can propose the treatment model to authorizing agencies and start its practical application.

Conclusion

Our main reason for selecting medical application-based model for fibromyalgia is because there are very less number of rheumatologists in the world. Even rheumatologists themselves overloaded with other diseases like arthritis, rheumatoid fever... etc. So, patients suffer a lot and have to consult other doctors like psychiatrist, who can't might not satisfy the patients as that rheumatologists can.

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ML Clinic AI and ML based Medical Evaluation

21 yrs./Male
C/O Generalized pain all over body *.* feb 2019

power 5/5
CPK **N**
CRP **N**
LDH **N**
EMG : **Myopathy Pattern**

?? Fibromyalgia
?? Metabolic Myopathy
?? Somatic Disorder

Plan
Muscle Biopsy (thigh)
Sr. CPK
Sr. Myositis Profile
MRI b/o arms & thigh

Adv.
Inj. Depomedrol 80mg
Tab. Shelcol 10D
Tab. Calcium Sachse 60k *4/month

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Figure 5: A sample case of type II.

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