Improving the Psychiatric Diagnostic Procedure With Machine Learning

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Doctors use patterns to classify what is wrong with a patient, as they identify the symptoms of a patient and infer what diagnosis the patient requires. Sometimes these patterns are obvious, and other times a doctor may have several theories from symptoms which then requires a patient to get a second opinion. The difference between an obvious diagnosis and a more inconspicuous one is the lack of empirical evidence. If an illness, injury, or some other issue has a physical symptom that is perceptible to a doctor and is also not a symptom shared by another medical issue, then this would be an obvious diagnosis made on empirical evidence. A laceration on the leg would be an easy diagnosis to make, as a doctor can physically see the issue the patient is suffering from. Other issues may not be as obvious, such as bone contusions or strep throat. However, to obtain empirical evidence of these ailments, society has invented and adopted tools such as x-ray machines and strep tests. Even if one cannot detect an issue from observation, tools will allow them to make decisions based on fact.

Not all fields of medicine are lucky enough to have empirical tests and procedures to deduce what a patient is suffering from. In the field of psychiatry, doctors are often bound by testimonial evidence. There are some mental health disorders that have physical symptoms, but some issues that revolve around problems of the identity, such as Bi-Polar Disorder, are sometimes not possible to detect in a quantitative manner. Instead, a psychiatrist must ask a patient if they have certain symptoms and try to build a case for a particular diagnosis. Other medical professions have an inductive diagnosis where facts proceed a theory. A psychiatrist is required to conduct a diagnosis procedure deductively, where they have a theory and prod the patient with questions until they can accept or deny it. Psychiatry is different from other medical

fields in this way; in other fields an illness causes symptoms, but in psychiatry the illness is defined by the symptoms.

Machine Learning (ML) is the application of computers to detect patterns in a data set. Humans are very good at detecting patterns, and using patterns has helped our economy, artistry, and, most importantly, our survival. Humans use the current state of a situation to determine what will happen next and then make a decision based on this inference. A program could be hard coded with human observations and use a decision tree to make an inference. However, this program will be limited by human observations, and if it is introduced to a data set that is not covered by the inputted observations, it may have unpredictable behavior. Instead, to cover a much broader range of cases, ML programs allow computers to detect the same patterns that humans detect. These programs can be trained to reduce the human effort needed to detect a pattern and even discover patterns that are too complex for humans to recognize.

Due to the lack of empirical data in psychiatric diagnoses, patients can often be misdiagnosed. Researchers are trying to make the diagnosis process better by utilizing ML to ultimately decrease this misdiagnosis. The diagnostic procedure is essentially pattern detection, so ML would ideally diagnose more consistently and efficiently. However, by simply using ML to classify a patient based on symptoms, you are inserting the same subjective issues into the program. Other ML approaches try to make the psychiatric diagnosis more like other medical fields and find what physical and empirical similarities patients with the same disorder have. Instead of employing the same patterns we have already discovered in a Traditional Machine Learning (TML) approach, an Empirical Machine Learning (EML) approach aims to find patterns that are too complex for humans to detect and have a more accurate diagnosis.

The Social Construction of Technology (SCOT), a theory of technology, describes how technology comes to be adopted and shapes human culture. SCOT posits that society is not shaped by technology, but rather human interaction shapes technology. Humans do not adopt new ways of life because of a technological breakthrough, but rather a technological breakthrough is a breakthrough because it furthers the ability of humans to live their life more conveniently. SCOT would argue that a technology that makes an existing convention in society more convenient would be adopted more quickly than a technology that reinvents that existing convention.

This thesis aims to show the advantage of EML over TML. Mental health disorders are conditions that millions of people suffer from, and even if there is a lack of understanding of many of the disorders, there are treatments that could help many people. The first part of treatment is correctly identifying the problem, and society cannot afford to continue to incorrectly diagnose or further exacerbate the problem by using TML to make a process that produces many misdiagnoses more efficient and prevalent. SCOT may seem to suggest the EML approach, however, this thesis aims to explain how SCOT would actually suggest the non-traditional approach that would yield a higher accuracy.

Social Construction of Technology (SCOT)

There is no question that technology has changed society. Inventions such as the internet, television, and phones have allowed people to be connected more than in any point in history. However, as SCOT describes, these inventions were allowed to change society because they didn't change any of our conventions. Before the television, people listened to the radio to hear

news and be entertained. Before the phone, people still communicated from a distance with letters. These inventions did not make humans become social creatures, but further enabled their ability to be social. If a revolutionary new technology was invented and drastically changed the way humans could live their lives, it might not in fact be revolutionary.

An example of an invention that could have revolutionized society if it was adopted is Esperanto. Esperanto was a language created by linguist L. L. Zamenhof. This language was created to be easier to learn from all other languages and allow everyone on the planet to be able to communicate with each other. One study showed that French students had the same mastery of German after 2,000 hours that they achieved after only 150 hours of studying Esperanto (Grin, 2005). This language clearly was effic dictionary translator would have to be used if someone spoke a different language. Despite existing for over 100 years, it is estimated that Esperanto only has around 10,000 fluent speakers (Lindstedt, 2010). Humans clearly want to speak with people from different nations, as we have adopted technologies such as Google Translate. The difference between Esperanto and Google Translate is that the former tries to change a social convention, while the ladder allows that convention to still exist.

SCOT helps explain how technologies are adopted in mainstream society, but in scientific fields, adoption seems to work differently. Every science student learns about Galileo being imprisoned for claiming the sun was the center of our solar system. However, every classroom teaches the heliocentric model today, showing that scientific progress eventually surpasses social conventions. Scientists could present new data supporting their model, and more scientists and public opinion might start to believe them. However, if Esperanto officials

came out every year parading the efficiency of their language and claiming how much better it is than a person's native tongue, they still might not learn it.

SCOT theory could still explain why this happens. The Catholic Church might not have liked being proven wrong by Galileo, but most people's lives aren't affected by accepting that the sun is the center of the solar system. Most people also have an understanding that scientific progress will only make their lives more comfortable. Simply looking at childbirth death rates for the mother and infant from the past and seeing how much they have declined with our understanding of hygiene and medicine should allow someone to see why well-evidenced scientific progress should always be accepted.

At first glance, SCOT may seem to claim that the TML approach is what society will accept. It takes the existing psychiatric diagnostic process and simply takes out the human effort required and makes it more accessible and efficient. However, the current diagnostic method isn't a convention in society that most people hold dear, like their language, and misdiagnosis rates may make it a convention that we should actively seek to eliminate. The EML approach may be even more comfortable to society because it is similar to how almost every other medical field conducts its diagnosis procedure. SCOT claims that human action shapes the technology we create and adopt. The scientific and medical communities clearly value empirical evidence, and therefore the EML approach would be, and should be, chosen over the TML approach.

Empirical Evidence

In any medical discipline, the diagnosis accuracy is constrained by the current understanding of the subject. One field of medicine that is very well understood is orthopedic

practice. Research and experience have illuminated exactly what happens to a bone during a break, sprain, strain, contusion, or fracture. If a patient cannot put weight down a leg, a doctor could then narrow the problem down to one of those issues. They could then use the swelling, discoloration, and shape of the bone to further reduce the number of possibilities. If a diagnosis still couldn't be made, or if the doctor just wanted to be sure, an x-ray machine could be used to concretely make the diagnosis empirical. Using this method, where evidence is collected until an informed decision is made, it is unlikely that two doctors would make different diagnoses. They might differ on how to treat the leg or what the timeline of recovery would be, but they would more than likely agree on the principal diagnosis.

The most important and influential portion of a diagnostic procedure would be the x-ray in the orthopedic example. A patient may not be able to tell the difference in feeling between a break and a sprain, and the external appearance of the issue may be very similar. Unless the bone is protruding from the leg, a doctor may not truly be able to tell if it is fractured or broken unless they could look inside of the person. Looking inside of a person would have required surgery and a lot of complications, and luckily the x-ray machine changed this. A doctor could now relatively safely look inside of a person and look at their bones. Although there was previously some empirical evidence that was related to the issue, this new technology allowed for the diagnosis to have primary empirical evidence.

The pursuit of medical research will always be to find the exact function of each part of the human body so that we know what to treat when something goes wrong. If a car's engine starts overheating, it can't just be doused in water and allowed to be kept running. Each part's function is known, so a mechanic can look at each part and tell which one is causing the issue

and fix or replace it. Doctors still have to try and treat patients even if we don't know what causes each condition. However, the advantage the mechanic has over the doctor is clear, and the comparison demonstrates the necessity of empirical knowledge to fix a problem.

Psychiatry Diagnosis

The brain is one of the most complex topics in medical research. Neuroscience research has given insight into the various regions of the brain, how neurons work, and the unfathomable amount of connections between neurons. A part of the brain is responsible for memory, but it is unknown exactly how neurons firing create what humans know as cognition. The digestion process is not like this. If a patient is having stomach pains after eating, a gastroenterologist knows exactly how each organ functions in the digestion process and can know functionally what is going wrong. A psychiatrist does not have this luxury and instead has to identify symptoms verbally in most cases and then make a diagnosis of what is happening in the brain based on this testimony.

In some cases, like a severe case of Schizophrenia, there may be some empirical evidence a doctor could find like inflammatory cytokines in the blood of a patient. However, in many minor cases of Schizophrenia, along with a vast amount of other disorders, there are not empirical tests that a doctor can rely on. Currently, a doctor has to diagnose a patient using the DSM-5 manual. This manual lists all currently accepted mental health disorders and allows a doctor to diagnose based on each disorder's criteria of symptoms. The psychiatrist must ask a patient questions to understand what symptoms they have. If a question regarding a certain symptom isn't asked, the patient may never divulge the information. A patient's tolerance of a

certain symptom may differ from another patient's tolerance. Therefore, it is the role of the psychiatrist to ask the correct questions, have some sort of baseline for each symptom, and then adjust the patient's severity rating of each symptom based on their own perception of the patient.

It is clear that this current method would cause many misdiagnoses. A doctor may not ask about a symptom because they already have a theory, a patient may lie, a patient may over exaggerate or under exaggerate, and a doctor could almost subconsciously place their theory in the patient's head. Bi-Polar Disorder is a disorder that has a very high misdiagnosis rate and leaves many patients that suffer from it without a correct diagnosis for many years. The entry in the DSM-5 manual states that people suffering from Bi-Polar I Disorder have suffered from a manic episode and a depressive episode (American Psychiatric Association, 2013). There are specific classifications of what constitutes both of these episodes, but a patient may not have a great memory or might not think that certain parts of their episode were dramatic enough to be mentioned. They may also be ashamed and not give the full story. Due to these factors, the Bi-Polar misdiagnosis rate is around 60 percent.

In the case of diagnosing Bi-Polar Disorder, the doctor must find a pattern in a patient's symptoms and episodes to classify it as such. They look at family history, medical history, current problems in that person's life, drug and substance abuse, and current and past symptoms. They use this information to create a theory that is not based on objective truth and fact, but instead on their own ability of the doctor to process patterns. This pattern detection might be able to eliminate disorders that the patient obviously doesn't have, but it might not be the best process to hone in on the exact diagnosis.

Despite how impressive human pattern recognition is, there should still be an effort to steer away from diagnostic methods that rely solely on this skill and instead create methods that focus on empirical evidence. Pattern recognition fails quite often and finds patterns where patterns don't actually exist. One example is Pareidolia, which explains how humans often see faces in non-human objects. A person can see a human face in a cloud or on a tree if it has any resemblance to a face's features. Obviously, a person can distinguish a cloud from a real human face because of the color, context, and many other distinct differences. However, in a medical field, this pattern detection error may not be as obvious. Diagnosis based on empiricism removes this human error to a large degree, as doctors are no longer trying to make sense of a pattern, but instead searching for a physical, objective finding.

Traditional Machine Learning (TML)

The current psychiatric diagnostic method is essentially a pattern recognition problem. Therefore, there have been several attempts to have computers mimic what doctors do and classify disorders based on a patient's testimony. Having a computer diagnosis would remove the need for a doctor to diagnose. This would remove the patient's time waiting for an appointment, the financial burden of seeing a doctor, and the doctor's bias and subjectivity. These common problems would be replaced with a program that was accessible, nearly free to provide, and dealt with patients more consistently.

A program of the TML approach could be deployed in countries that do not have great access to psychiatrists. This would allow a much greater amount of patients to have access to medical consultation. However, this problem would have the same issues as the diagnostic

process has. If the machine was trained on Bi-Polar patients, for example, and nearly 60 percent (Ghouse, 2013) of patients with Bi-Polar Disorder were misdiagnosed, then the training data would be wrong, and the TML would continue misdiagnosing people. The machine may find patterns more consistently than a doctor, but their initial patterns they form will be from the patterns already derived by doctors.

This issue is evidenced by a TML approach that still had a 36% misdiagnosis rate on patients for PTSD using only background information. It is suggested that only 2-11% of people with PTSD actually have an official diagnosis (Meltzer et al., 2012), and this is due to the symptoms overlap with other disorder's symptoms. Doctors know the limitations of the current diagnostic method and therefore often err on the side of caution with a diagnosis. A TML could have degrees of confidence for a diagnosis, but they might not have the human sensibility to choose not to officially diagnose a patient.

The SCOT might explain why many researchers are eager to try a TML approach. It would take the existing convention and make it easier for humans to propagate. However, the outcome of many of these studies shows that it will only allow the issues of the traditional diagnoses to propagate as well. The TML approach's biggest issue is that it does not rely on empirical evidence, and instead on the DSM-5 criteria and other qualitative features of a patient. Society seems to embrace new medical practices that increase the quality of life. Thus, using SCOT, it becomes clear that society would not embrace the TML approach, as it does not truly increase the quality of their life or medical care. The ML approach that would be adopted by SCOT would be one that is based on empirical evidence and that has a lower misdiagnosis rate.

Empirical Machine Learning (EML)

It is simpler for a doctor to diagnose a patient with strep throat by using a step test, rather than feeling their swollen glands, looking down their throat, and asking the patient if it hurts to swallow. All of those observations can lead a doctor to think it is strep throat, but those symptoms can exist in other illnesses as well. The strep test eliminates almost all doubt and gives the doctor a definitive answer based on data.

The EML approach aims to create the litmus tests for mental health disorders. Instead of using ML to find patterns in qualitative and testimonial evidence, EML tries to find patterns using empirical data. As mentioned previously, cases of Schizophrenia are often accompanied by inflammatory cytokines in the blood. The EML could take the background information of a patient and accompany it with data about the patient's blood or brain to try and make a diagnosis. In the same study that found nearly 36% of PTSD patients were misdiagnosed using TML with background information only, the correct diagnosis rate rose up to 82%. When using data taken over longer periods of time, this rate further rose to 93% (Galatzer-Levy et al., 2017).

Even if dozens of doctors agree that a particular patient has certain symptoms, and they could be classified in the DSM-5 for a certain disorder, a patient with the same diagnosis may not have the exact same issue in their brain. Data allows a diagnosis to be less about the symptoms, and more about the actual condition of the brain. However, for data to be related to a certain disorder, a physical pattern must be found. One study aims to find the physical difference between a brain of a healthy individual and a brain of a depressed individual (Sacchet et al., 2015). These differences might not be obvious to a doctor, but if given enough sets, a ML program may be able to detect several patterns.

One disadvantage of the EML approach is the cost. In the TML approach, this program would be relatively cheap for people to use all around the world. Using the EML approach, testing would have to be completed. It would not be as simple as a strep test and could require brain scans or blood tests. In the case of testing patients for PTSD, it required extensive testing, as it took one month of testing to get 93% accuracy. For the EML approach to truly revolutionize the way diagnosis is done, there would have to be cheaper and faster tests developed to actually quantify the condition of a patient's brain.

Following SCOT, this approach appears to be the one that would be accepted by society. It is important for a new technology to either increase efficiency of a convention that society enjoys, or revolutionize a convention that society doesn't like. There are clear issues with the current diagnostic method, and seeing the results of TML vs EML approaches, it is clear that these issues lie within the lack of empirical evidence. The EML approach will decrease the number of misdiagnosis, and ultimately lead to better public health, which will then influence its adoption in the mental health field.

Conclusion

Too many patients are misdiagnosed for their mental health disorders and, looking at the current diagnosis approach, it is easy to see why. There is too much room for insertion of personal bias and other forms of human error. Even if the DSM-5 manual adds some objectivity, it is still a manual that was created by other doctors. There is a lack of empiricism in this process, and while a TML approach would allow more people to have access to a diagnosis, the EML approach is the only one that would help the accuracy of diagnosis in a meaningful way.

While people in countries that would previously not have a diagnosis may have one under TML, if it is a misdiagnosis then it might not help them at all. Making decisions based on empirical data in science and health is a very useful convention, and therefore the EML approach should be adopted in society as it is the approach that places value on objectivity.

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