

How can Machine learning be used in different ways to predict bipolar states?

Joakim I. Frogner



Thesis submitted for the degree of
Master in Programming and Networks
60 credits

Department of Informatics
Faculty of mathematics and natural sciences

UNIVERSITY OF OSLO

Spring 2018

How can Machine learning be used in different ways to predict bipolar states?

Joakim I. Frogner

© 2018 Joakim I. Frogner

How can Machine learning be used in different ways to predict bipolar states?

<http://www.duo.uio.no/>

Printed: Reprosentralen, University of Oslo

Abstract

Contents

I	Introduction	1
1	Introduction	3
1.1	Motivation	3
1.2	Thesis overview	3
2	Background	5
2.1	Bipolar disorder	6
2.2	Machine learning	7
2.3	Machine learning strategies	8
2.3.1	Supervised learning	8
2.3.2	Unsupervised learning	9
2.3.3	Semi-supervised learning	9
2.4	Machine learning approaches	9
2.4.1	Decision tree learning	9
2.4.2	Neural networks	10
2.5	How can machine learning help predicting states of people with bipolar disorder?	11
2.6	Related work	12
2.7	Challenges	13
2.8	Ethical concerns	14
2.9	The dataset	15
2.10	What to do in this project	15
II	The project	17
3	Planning the project	19
III	Conclusion	21
4	Results	23

List of Figures

List of Tables

2.1	Training data set: days a person went out for a run	10
-----	---	----

Preface

Part I

Introduction

Chapter 1

Introduction

1.1 Motivation

Statistics

- Data shows that 5,890,000 adults are diagnosed with bipolar disorder in the USA (2,65% of the adult population) [find better source].

Ways to use the results of this study?

1.2 Thesis overview

[Fill in later]

Chapter 2

Background

2.1 Bipolar disorder

Bipolar disorder is the disorder where you experience extreme mood swings. One day you can feel amazing and everything is fine, but the next day you feel like you don't belong anywhere in this universe. Mood swings in general is not something that you should be concerned about. It is however the extreme cases where your mind turns 180 degrees from day to day that is the main symptom of bipolar disorder. There is not really a specific type of people that get this; they can be of any age and any gender, but most people that suffer from it find out (by having an experience or episode) around age 25 [3].

When talking about bipolar disorder, we often separate between the states *normal*, *mania* and *depression*. The last two are the states we usually talk about, since a normal state isn't that interesting. These two states are very different, but they have some similarities, for example sleeping problems.

When a bipolar person is in a manic state, he/she may do things that they never would have intended doing, like spending a lot of money on items they really don't need, or abusing drugs/alcohol. They may also feel really excited or powerful [2].

A bipolar patient is in a depressive state when he or she is in a bad mood swing. They can stop doing everything they usually like to do, and lie down in bed all day with no motivation to do anything useful. They may feel useless and that they don't belong here, or being guilty of something they may or may not have done. In some cases, a depression may even end up with suicidality, where the person either just thinks of death, or actually attempt suicide (actually 20% of people diagnosed with bipolarity commit suicide [3]).

The frequency of these symptoms can vary. One year they can have these mood swings every day for several weeks at the time, and the next they get them less frequent, like once every month.

We also separate between bipolar disorder type I and II, with the main difference being that the manic episodes are way more aggressive in type I [1].

Statistics say that bipolarity is genetically inheritable, with 23% chance of getting a child with bipolar disorder if one parent is bipolar, and 66% if both parents are [3].

2.2 Machine learning

Machine learning is the field of computer science where you basically throw a lot of data into an algorithm and expect it to give you answers to whatever you prefer, with as little work as possible. This was not the case in the early days of the technology, but nowadays it is a lot easier with all the different frameworks and tools available.

Machine learning is a great and almost ‘magical’ technology, but only if you do it right. First you need to have enough data to feed into the algorithm, and to be efficient when training the model on a large dataset, which you need to be if you want your result quickly, you need good hardware. You can get away with a decent CPU if you just want to test it out on a small dataset, but if you really want to do machine learning, then you need a good GPU. The reason why GPUs are so much better than CPUs on this specific task, is because the CPUs are designed for flexibility and general computing workloads. The GPUs on the other hand, are designed to do the same instructions over and over again in parallel. This makes GPUs a lot more efficient for machine learning, and especially for deep neural networks [11].

Now how do you do the actual machine learning? Well there are many different approaches to this, which I will discuss in the next sections, but say you want to use a neural network for your task. Then your next step should be to choose a framework. You can of course do everything yourself, but why reinvent the wheel when there are so many good frameworks and tools already out there?

The programming language **Python** is great for machine learning in my (and many other peoples) opinion. It is structured in a way such that it really looks like pseudo-code, and this is perfect because we don’t want to spend time on weird syntax rules in another language. For Python, you have a popular framework called **TensorFlow** which is developed by Google. This allows you to build models easily, and also execute the training and testing. Before you get started with TensorFlow, do a quick google search to see if someone else has already done something similar to what you are trying to achieve, and if you find something, odds are that your neural network model can be similar, if not identical to it. If not, then you have to sit down and actually make the model yourself.

For the model implementation part, whether you found a model online or want to build it yourself, you can of course do it in TensorFlow, but there is an easier way. **Keras** is also a popular framework that is most commonly used together with TensorFlow. On their documentation website [7], they see their framework as ‘A high-level neural networks API, written in Python and capable of running on top of TensorFlow, CNTK or Teano’.

Following their ‘30 seconds to Keras’ guide [7], you can create a ‘sequential’ model with ‘dense’ layers, configure its learning process (compile), then fit, train, evaluate and predict with just a few lines of code:

Source Code 2.1: 30 Seconds to Keras

```
1  from keras.models import Sequential
2  from keras.layers import Dense
3
4  model = Sequential()
5
6  model.add(Dense(units=64, activation='relu', input_dim=100))
7  model.add(Dense(units=10, activation='softmax'))
8
9  model.compile(loss='categorical_crossentropy',
10               optimizer='sgd',
11               metrics=['accuracy'])
12
13  model.fit(x_train, y_train, epochs=5, batch_size=32)
14  loss_and_metrics = model.evaluate(x_test, y_test, batch_size=128)
15  classes = model.predict(x_test, batch_size=128)
```

So, as long as you know your theory, and can decide which model to use (and either find a good implementation of that model or create it yourself), you can easily do machine learning. One important task you have to do, is to make the dataset ready. This is the boring and tedious part of machine learning, but it has to be done in order for making it possible to train the model on it.

2.3 Machine learning strategies

Picking the right machine learning model can be quite difficult, especially if you don't have any experience from earlier. There are a couple of different *strategies* you can choose from when deciding on a machine learning model. These are called *Supervised and unsupervised learning*, and you need to look at your dataset and how it is structured to find out which one to use. The following sections will be a description of the strategies, to make the decision easier.

2.3.1 Supervised learning

This is the machine learning strategy where both input and desired output data are provided [10]. You can use this if you want to train a model to classify letters in the alphabet, or anything else where you have a dataset with both input and output data (for the alphabet, images of letters are input data and the actual letters are the output data). If you train this alphabet model, you will be able to input a completely new image of a letter, and the model will classify it to the letter it most likely fits. This kind

of supervised learning is called *Classification*, and is *the problem of assigning new observations to the class they most likely belong, based on a classification model built from labeled training data* [9].

Another kind of supervised learning is called *Regression*, and is all about predicting (or estimating) a value. A classic example for regression learning is predicting income, using *features* like home location, job title, field of study, years of education and years of experience. We call these features *categorical* (first three) and *numerical* (last two) [8].

2.3.2 Unsupervised learning

Another strategy is *Unsupervised learning*. This is what you want to use if you have a dataset without the same meaning as in a dataset for supervised learning. The items may not have a fixed answer, like the letters in the alphabet are. It is useful when you have *unlabeled* data, and want to for instance group data together in what we call a *cluster*. It may not be as commonly used as supervised learning, but unsupervised learning can also be very useful in some cases; like grouping addresses together in neighborhoods if you have a unsorted list of addresses as a dataset.

2.3.3 Semi-supervised learning

Now, you may not always want to use one of the strategies above. Looking at your dataset you may want something in between; a combination of labeled and unlabeled data. This is when semi-supervised learning comes in handy. For example if you have a lot of data to give labels to in your dataset, it can be simply too much work. I won't go deep into details about how this works, but I think it is important to mention it because of its usefulness.

2.4 Machine learning approaches

When you know whether you want to use supervised learning, unsupervised learning or something in between, you need to select an approach. I call them approaches because you use these regardless of the strategy you end up using; most of them (with the exception of *reinforcement learning*, which I will come back to) work in both supervised and unsupervised learning. There are a lot of different approaches available, and I will describe some of them, namely those I will use in the main parts of this thesis.

2.4.1 Decision tree learning

In computer science, trees are data structures commonly used to describe something that *branches out* based on different input. For example a tree can be a representation of how the frequency of letters in the alphabet are distributed in a text file, so that the text file can be compressed optimally. I won't go into details about how this works, but my point is that tree-structures are very common in most fields of computer science.

Day	Temperature	Outlook	Humidity	Wind	Run
1	15 C	Sun	Low	Strong	Yes
2	6 C	Rain	High	Weak	No
3	15 C	Rain	Medium	Strong	Yes
4	6 C	Overcast	High	Medium	Yes
5	15 C	Sun	Low	Weak	No
6	12 C	Overcast	Medium	Weak	No
7	12 C	Sun	Medium	Medium	Yes

Table 2.1: Training data set: days a person went out for a run

In machine learning, we can apply the tree-structures as *decision tree learning*. And in this approach, we set up all the different outcomes (with the training data set) of a specific question in a tree. Let's say you want to predict whether or not a person will run outside on a specific day. Then it makes sense that the training set contains weather information. The different data in the training set is called attributes, and picking these correctly is important for the quality of the prediction.

Table 2.1 contains data about whether a person went outside for a run or not for a week (just an example, not real data). Here the first 4 (excluding "Day") columns (Temperature, Outlook, Humidity and Wind) is the "predictors" and the last column (Run) is the "target". To use this table in decision tree learning, we need to view it as a tree, with one of the predictors as root node and the targets as leaf nodes.

How we choose the tree structure is critical to the performance of the machine learning, and we need to use a good tree building algorithm. The most common algorithm to use in this situation, is the *ID3* algorithm made by J. R. Quinlan. It is a top-down, greedy search through the space of possible branches with no backtracking [5]. The way this happens is by calculating *Entropy* and *Information Gain*. The idea is to recursively choose the predictor that has the highest information gain and generate a tree structure. With an optimal tree, you can create decision rules by simply following the tree down with new data.

Random Forest

2.4.2 Neural networks

General idea

Deep learning

Long Short-Term Memory Recurrent Neural Network (LSTM RNN)

2.5 How can machine learning help predicting states of people with bipolar disorder?

2.6 Related work

List related work and discuss...

2.7 Challenges

Describe some challenges...

2.8 Ethical concerns

Describe some ethical concerns...

2.9 The dataset

The dataset I will use in this project [6] was collected for another study for motor activity in schizophrenia and major depression. With the data about schizophrenia stripped out, this dataset is sufficient for my thesis. It contains activity level data for 23 bipolar and unipolar patients, and 32 non-depressed contributors. From now on, I will refer to the bipolar/unipolar group as the *condition group*, and the non-depressed group as the *control group*. This is also done in the dataset details [4].

2.10 What to do in this project

My problem statement is "How can Machine learning be used in different ways to predict bipolar states?", which indicates that this project will contain both some classification and some regression.

To do this, I will use all the algorithms I have specified, beginning with the easiest ones (decision tree learning and random forest), before I try neural networks.

Part II

The project

Chapter 3

Planning the project

Part III

Conclusion

Chapter 4

Results

Bibliography

- [1] *Bipolar 1 Disorder and Bipolar 2 Disorder: What Are the Differences?* Accessed: 14.03.2018. URL: <https://www.healthline.com/health/bipolar-disorder/bipolar-1-vs-bipolar-2>.
- [2] *Bipolar disorder*. Accessed: 14.03.2018. URL: <https://familydoctor.org/condition/bipolar-disorder/>.
- [3] *Bipolar disorder statistics*. Accessed: 14.03.2018. URL: <https://www.statisticbrain.com/bipolar-disorder-statistics/>.
- [4] *Dataset details*. Accessed: 08.05.2018. URL: <http://datasets.simula.no/depresjon/>.
- [5] *Decision Tree*. Accessed: 08.05.2018. URL: http://www.saedsayad.com/decision_tree.htm.
- [6] Enrique Garcia-Ceja et al. 'Depresjon: A Motor Activity Database of Depression Episodes in Unipolar and Bipolar Patients'. In: *Proceedings of the 9th ACM on Multimedia Systems Conference*. MMSys'18. Amsterdam, The Netherlands: ACM, 2018. DOI: 10.1145/3204949.3208125. URL: <http://doi.acm.org/10.1145/3204949.3208125>.
- [7] *Keras documentation*. Accessed: 15.03.2018. URL: <https://keras.io>.
- [8] *Machine Learning for Humans, Part 2.1: Supervised Learning*. Accessed: 11.04.2018. URL: <https://medium.com/machine-learning-for-humans/supervised-learning-740383a2feab>.
- [9] *Machine Learning for Humans, Part 2.2: Supervised Learning II*. Accessed: 11.04.2018. URL: <https://medium.com/machine-learning-for-humans/supervised-learning-2-5c1c23f3560d>.
- [10] *What is supervised learning?* Accessed: 11.04.2018. URL: <https://searchenterpriseai.techtarget.com/definition/supervised-learning>.
- [11] *Why are GPUs well-suited to deep learning?* Accessed: 15.03.2018. URL: <https://www.quora.com/Why-are-GPUs-well-suited-to-deep-learning>.