Calculating Heart Rate Values from an Electrocardiogram Using Multilayer Perceptron

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INTRODUCTION

As obesity becomes a larger problem in the United States, it is important for individuals to exercise regularly and to measure their heart rate as they are doing so. By taking into account their heart rate at various times of the day, individuals can monitor their fitness level and detect possible health problems. Although there are numerous smartwatches and fitness trackers in the market that claim to "effectively track a person's heart rate," most are inaccurate and provide false information to the user. **A need therefore arises to investigate how to accurately calculate the heart rate of a user.**

RESEARCH METHODOLOGIES

A primarily qualitative evaluation research was split into two parts:

1. Conducted research to understand the topics of **perceptron**, **linear regression**, **neural networks**, and **multilayer perceptron** by utilizing online videos and websites
2. Worked with my mentor to create a multilayer perceptron program (MLP) that could calculate the heart rate from an electrocardiogram (ECG) graph

Research Question: What is the most effective method to create an AI algorithm that calculates the heart rate from an electrocardiogram?

MACHINE LEARNING CONCEPTS

Perceptron
- Simplest neural network possible - the model of a single neuron
- Consists of one or more inputs, a processor, and one output
- Known as a linear binary classifier because it separates a cluster of points into two groups
- Provide perceptron with inputs with known output and the program will "learn" the line of best fit using an iterative learning process

Linear Regression
- Calculates the line of best fit for a set of points
  - Finds the slope and y-intercept for a simple line
- Computes the minimum of a cost function (measures how close a prediction is to the right value)
  - By minimizing the error iteratively, it learns the coefficients of the line

Neural Networks
- Composed of connecting two layers of linear regression
  - Output of first regression is the input of the second regression
- A non linear layer is added to the network so that it can predict curved lines (ReLU is the most common)
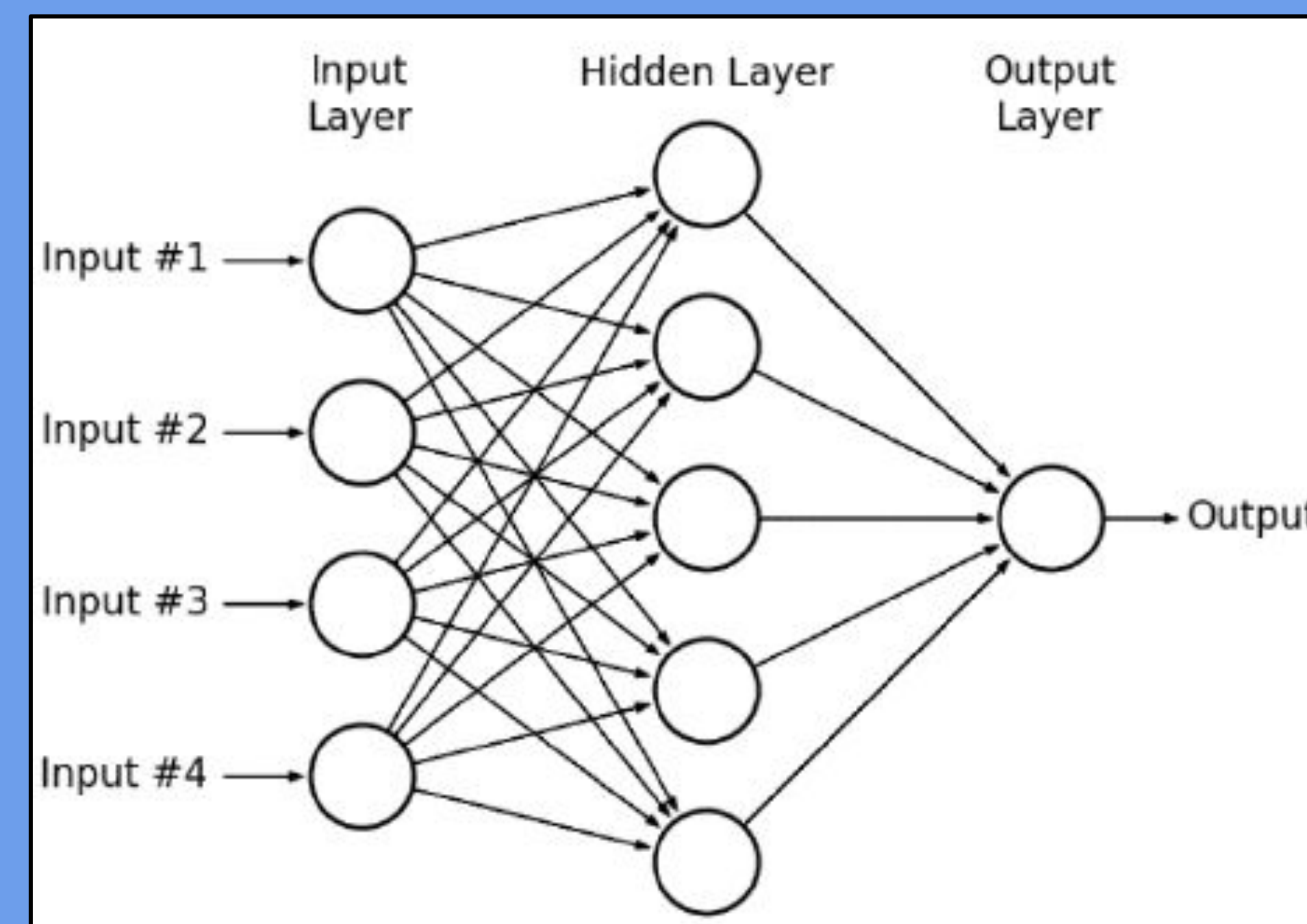
Multilayer Perceptron
- Based on the neural network concepts, a deep learning network can be created by simply adding more layers

DATA AND ANALYSIS

After completing research on the four topics of perceptron, linear regression, neural networks, and multilayer perceptron, an ECG implementation was built upon the learned concepts.

We used a three-layer multilayer perceptron:

ECG data was collected by my mentor's company, Huami, with an ECG sensored wristband.

Validation results for calculated heart rate:

Cases within a difference of 0 beats: 53%

Cases within a difference of 10 beats: 73%

A multilayer perceptron relies upon a large amount of data. We only used 800 pieces of ECG data to train our multilayer perceptron, and the calculations were not as accurate as they could have been. **We need to use more data so that our multilayer perceptron can run through more iterations and calculate a more accurate heartbeat rate.** It is, however, a very effective method of using machine learning to calculate the heart rate from an electrocardiogram. We simply did not have enough data and time to train our multilayer perceptron to its full potential.

Although we could develop a program that detects the R-peaks from an ECG to calculate the heart rate, its overall accuracy is not very high due to signal disruptions and the accuracy cannot improve with more iterations, making multilayer perceptron our best option for calculating the heart rate.

CONCLUSIONS, IMPLICATIONS, AND NEXT STEPS

Over the course of this project, I learned the basics of machine learning by researching the four underlying topics of artificial intelligence: **perceptron, linear regression, neural networks,** and **multilayer perceptron.**

Although my mentor had written the code for each of the concepts and the final electrocardiogram implementation, I was able to understand the fundamental concepts of artificial intelligence, which was my primary goal for this project. **Learning the code and writing the programs myself will be another project for me to work on in the future.**

My mentor presented the topic of electrocardiogram applications in fitness watches because that is what his company, Huami, was working on at the time. Calculating the heart rate from an electrocardiogram was a great application for the machine learning concepts that I have been researching.

In the future, I would like to expand on my knowledge of these four topics of AI and research in depth the applications of multilayer perceptrons. In the field of artificial intelligence, my project was relatively simple and I barely touched upon what AI can accomplish. Artificial intelligence is a new field in our society that is constantly expanding, and I would definitely like to continue studying it in college.

ACKNOWLEDGEMENTS / REFERENCES

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