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# Performance Optimization of a Convolutional Neural Network for Real-Time Pulse Detection

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## Abstract

During CPR, automatically detecting pulse can save precious seconds compared to manual palpation. While devices exist for pulse detection<sup>2</sup>, there are limited options when it comes to rigorous detection algorithms. This paper will explore convolutional neural networks (CNNs) as an option for the real-time binary classification of a pulse reading. Using a pulse wave dataset, we swept several critical hyperparameters, optimizing for accuracy. Our final model has achieved an accuracy of [TODO]%, indicating that the use of CNNs for pulse classification is viable for real-time detection.

## 1 Input Data

### 1.1 Dataset Description

The dataset used for this work was collected as part of UBC ECE Capstone Group LS-15's project. It is a series of four second segments, each a time series of pulse data described as sensor values (arbitrary units). Data is sampled at 60Hz, meaning each sample is 240 points in length. A typical sample might look like the plot as shown in figure 1.

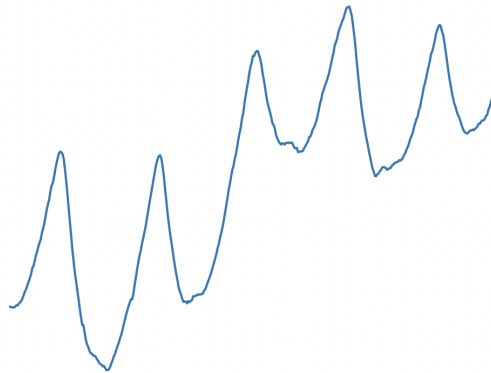


Figure 1: Typical pulse sample

Each data point (four second segment) is labelled by hand as either having, or not having a pulse. The sample in figure 1 would be labelled as having a pulse. Labelling was performed by non-experts, and as such is expected to have some error.

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\*This is my dog, I like using 'we' on formal papers.

<sup>2</sup>For example, my capstone group's device.

The dataset comprises of 701 data points, collected in a variety of test conditions. The distribution of the data is shown in figure 2. 61% of data has a pulse, while 39% does not.

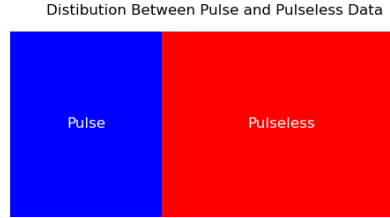


Figure 2: Dataset distribution

Although many samples such as figure 1 may have an easily visible pulse, some samples are more challenging, with spikes created by noise or weak pulse signals.

## 1.2 Preprocessing

As seen in figure 1, data often has high and low frequency noise that we would like to filter. After flooring the data by setting the lowest value to 0, we apply a band pass filter as seen in figure 3. This passes frequencies from 0.5Hz to 5Hz, which translates to 30 BPM and 300 BPM, considered the possible range for the human heart rate.

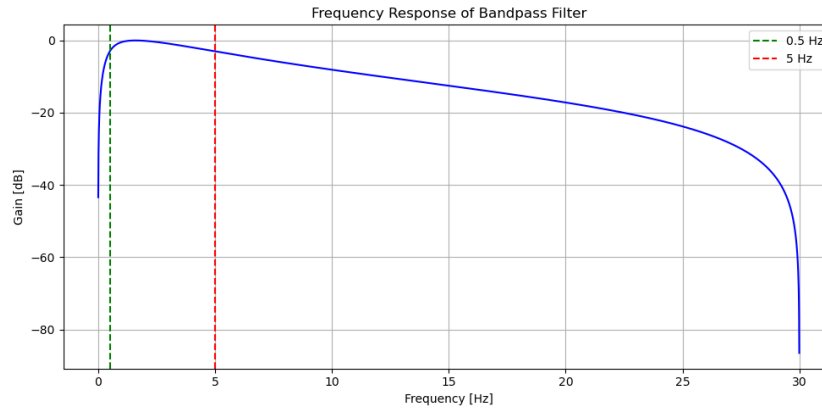


Figure 3: Frequency response of band pass filter

Data often has a strong baseline shift. To eliminate this, we fit a 4th degree polynomial to the data, and then remove that, treating it as a baseline. An example of a fitted polynomial can be found in figure 4

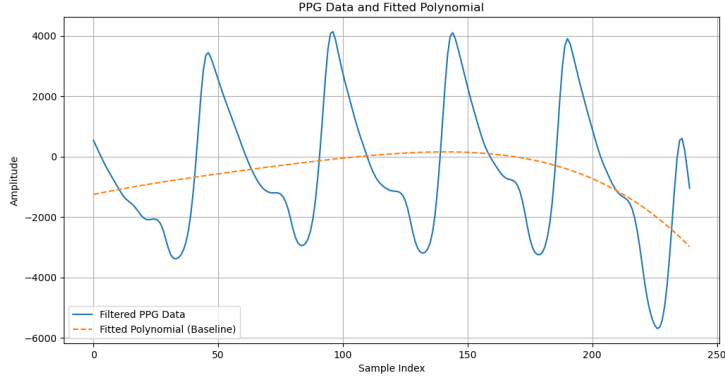


Figure 4: Polynomial fit to data sample

Finally, data is normalized. The full process makes our data more uniform, allowing for our CNN to focus on features that differentiate pulse.

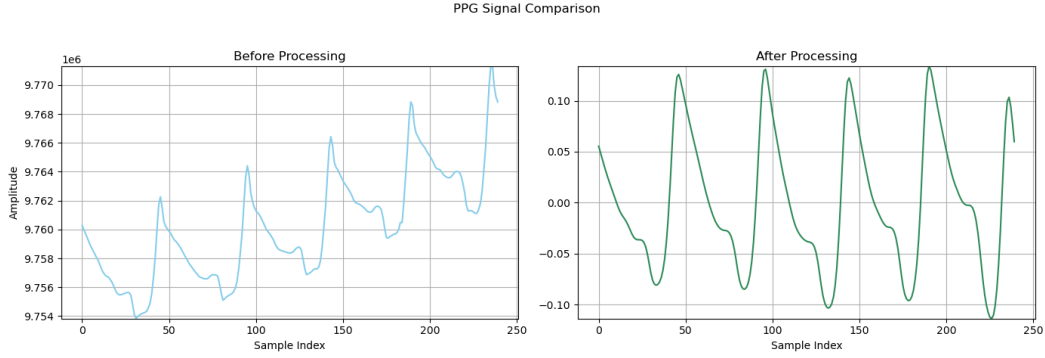


Figure 5: Before and after data preprocessing

Although this preprocessing can radically change data points, this results in clean data that performs well in our classification model.

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<https://neurips.cc>

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## 2 General formatting instructions

The text must be confined within a rectangle 5.5 inches (33 picas) wide and 9 inches (54 picas) long. The left margin is 1.5 inch (9 picas). Use 10 point type with a vertical spacing (leading) of 11 points. Times New Roman is the preferred typeface throughout, and will be selected for you by default. Paragraphs are separated by  $\frac{1}{2}$  line space (5.5 points), with no indentation.

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For the final version, authors’ names are set in boldface, and each name is centered above the corresponding address. The lead author’s name is to be listed first (left-most), and the co-authors’ names (if different address) are set to follow. If there is only one co-author, list both author and co-author side by side.

Please pay special attention to the instructions in Section 4 regarding figures, tables, acknowledgments, and references.

## 3 Headings: first level

All headings should be lower case (except for first word and proper nouns), flush left, and bold.

First-level headings should be in 12-point type.

### 3.1 Headings: second level

Second-level headings should be in 10-point type.

#### 3.1.1 Headings: third level

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**Paragraphs** There is also a `\paragraph` command available, which sets the heading in bold, flush left, and inline with the text, with the heading followed by 1 em of space.

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The `natbib` package will be loaded for you by default. Citations may be author/year or numeric, as long as you maintain internal consistency. As to the format of the references themselves, any style is acceptable as long as it is used consistently.

The documentation for `natbib` may be found at

<http://mirrors.ctan.org/macros/latex/contrib/natbib/natnotes.pdf>

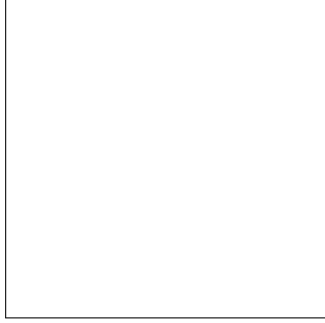


Figure 6: Sample figure caption.

Of note is the command `\citet`, which produces citations appropriate for use in inline text. For example,

```
\citet{hasselmo} investigated\dots
```

produces

Hasselmo, et al. (1995) investigated...

If you wish to load the `natbib` package with options, you may add the following before loading the `neurips_2025` package:

```
\PassOptionsToPackage{options}{natbib}
```

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```
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```

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Note that footnotes are properly typeset *after* punctuation marks.<sup>4</sup>

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All artwork must be neat, clean, and legible. Lines should be dark enough for purposes of reproduction. The figure number and caption always appear after the figure. Place one line space before the figure caption and one line space after the figure. The figure caption should be lower case (except for first word and proper nouns); figures are numbered consecutively.

You may use color figures. However, it is best for the figure captions and the paper body to be legible if the paper is printed in either black/white or in color.

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<sup>3</sup>Sample of the first footnote.

<sup>4</sup>As in this example.

Table 1: Sample table title

Part		
Name	Description	Size ( $\mu\text{m}$ )
Dendrite	Input terminal	$\sim 100$
Axon	Output terminal	$\sim 10$
Soma	Cell body	up to $10^6$

#### 4.4 Tables

All tables must be centered, neat, clean and legible. The table number and title always appear before the table. See Table 1.

Place one line space before the table title, one line space after the table title, and one line space after the table. The table title must be lower case (except for first word and proper nouns); tables are numbered consecutively.

Note that publication-quality tables *do not contain vertical rules*. We strongly suggest the use of the `booktabs` package, which allows for typesetting high-quality, professional tables:

<https://www.ctan.org/pkg/booktabs>

This package was used to typeset Table 1.

#### 4.5 Math

Note that display math in bare TeX commands will not create correct line numbers for submission. Please use LaTeX (or AMSTeX) commands for unnumbered display math. (You really shouldn't be using  $\$$  anyway; see <https://tex.stackexchange.com/questions/503/why-is-preferable-to> and <https://tex.stackexchange.com/questions/40492/what-are-the-differences-between-align-equation-and-displaymath> for more information.)

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Please prepare submission files with paper size "US Letter," and not, for example, "A4."

Fonts were the main cause of problems in the past years. Your PDF file must only contain Type 1 or Embedded TrueType fonts. Here are a few instructions to achieve this.

- You should directly generate PDF files using `pdflatex`.
- You can check which fonts a PDF files uses. In Acrobat Reader, select the menu Files>Document Properties>Fonts and select Show All Fonts. You can also use the program `pdf fonts` which comes with `xpdf` and is available out-of-the-box on most Linux machines.
- `xfig` "patterned" shapes are implemented with bitmap fonts. Use "solid" shapes instead.
- The `\bbold` package almost always uses bitmap fonts. You should use the equivalent AMS Fonts:

```
\usepackage{amsfonts}
```

followed by, e.g., `\mathbb{R}`, `\mathbb{N}`, or `\mathbb{C}` for  $\mathbb{R}$ ,  $\mathbb{N}$  or  $\mathbb{C}$ . You can also use the following workaround for reals, natural and complex:

```

\newcommand{\RR}{\mathbb{R}} %real numbers
\newcommand{\Nat}{\mathbb{N}} %natural numbers
\newcommand{\CC}{\mathbb{C}} %complex numbers

```

Note that `amsfonts` is automatically loaded by the `amssymb` package.

If your file contains type 3 fonts or non embedded TrueType fonts, we will ask you to fix it.

## 5.1 Margins in L<sup>A</sup>T<sub>E</sub>X

Most of the margin problems come from figures positioned by hand using `\special` or other commands. We suggest using the command `\includegraphics` from the `graphicx` package. Always specify the figure width as a multiple of the line width as in the example below:

```

\usepackage[pdftex]{graphicx} ...
\includegraphics[width=0.8\linewidth]{myfile.pdf}

```

See Section 4.4 in the graphics bundle documentation (<http://mirrors.ctan.org/macros/latex/required/graphics/grfguide.pdf>)

A number of width problems arise when L<sup>A</sup>T<sub>E</sub>X cannot properly hyphenate a line. Please give LaTeX hyphenation hints using the `\-` command when necessary.

## Acknowledgments and Disclosure of Funding

Use unnumbered first level headings for the acknowledgments. All acknowledgments go at the end of the paper before the list of references. Moreover, you are required to declare funding (financial activities supporting the submitted work) and competing interests (related financial activities outside the submitted work). More information about this disclosure can be found at: <https://neurips.cc/Conferences/2025/PaperInformation/FundingDisclosure>.

Do **not** include this section in the anonymized submission, only in the final paper. You can use the `ack` environment provided in the style file to automatically hide this section in the anonymized submission.

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- [1] Alexander, J.A. & Mozer, M.C. (1995) Template-based algorithms for connectionist rule extraction. In G. Tesauro, D.S. Touretzky and T.K. Leen (eds.), *Advances in Neural Information Processing Systems 7*, pp. 609–616. Cambridge, MA: MIT Press.
- [2] Bower, J.M. & Beeman, D. (1995) *The Book of GENESIS: Exploring Realistic Neural Models with the GEneral NEural Simulation System*. New York: TELOS/Springer-Verlag.
- [3] Hasselmo, M.E., Schnell, E. & Barkai, E. (1995) Dynamics of learning and recall at excitatory recurrent synapses and cholinergic modulation in rat hippocampal region CA3. *Journal of Neuroscience* **15**(7):5249-5262.

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The reviewers of your paper will be asked to use the checklist as one of the factors in their evaluation. While "[Yes]" is generally preferable to "[No]", it is perfectly acceptable to answer "[No]" provided a proper justification is given (e.g., "error bars are not reported because it would be too computationally expensive" or "we were unable to find the license for the dataset we used"). In general, answering "[No]" or "[NA]" is not grounds for rejection. While the questions are phrased in a binary way, we acknowledge that the true answer is often more nuanced, so please just use your best judgment and write a justification to elaborate. All supporting evidence can appear either in the main paper or the supplemental material, provided in appendix. If you answer [Yes] to a question, in the justification please point to the section(s) where related material for the question can be found.

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