Highlights

Bayesian classification of Parkinson's disease patients using fMRI data

Maryam Amirmazlaghani,Amin Amini

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Bayesian classification of Parkinson's disease patients using fMRI data

Maryam Amirmazlaghani[a,*], Amin Amini[a]

[a]Department of Computer Engineering and Information Technology, Amirkabir University of Technology, Tehran, Iran

ARTICLE INFO

Keywords:
Functional magnetic resonance imaging (fMRI)
Resting-state
Disease diagnosis
Bayesian deep learning
Convolutional neural network (CNN)

ABSTRACT

The goal of resting-state functional magnetic resonance imaging (fMRI) is to investigate the brain's functional connections by using the temporal similarity between blood oxygenation level dependent (BOLD) signals in different regions of the brain "at rest" as an indicator of synchronous neural activity. However having different images of patients' brains despite the sequential time based information, may contain enough data to investigate their brains and enables us to recognize some diseases. In this paper, we propose a novel method to automatically extract these non time sequence based information using a Bayesian deep learning algorithm based on convolutional neural network (CNN). Instead of using some predefined points of interest (POIs) we use the whole data in training phase so those points of the brain which do not contain related information about the disease will be ignored automatically by the trained model. Moreover this method does not take any assumptions about disease, patients, etc., makes it a possible universal disease diagnosis approach to differentiate diseases having an impact on brain functionality. This method is a supervised algorithm with small amount of calculations using three dimensional CNN. Each fMRI scan (which contains t time slices of brain) of patients will divided into t different 3D images enabling us to make our dataset much bigger in number and calculations way simpler. Subsequently all of these image are fed to a Bayesian network similar to LeNet-5 (but in three dimensions) to train our model. Then to determine if a person is suffering from Parkinson's or not, we test his/her t fMRI images and get t different results which leads to a fraction (probability) of how unhealthy his/her brain is and if that fraction is above 0.5 we can classify that sample as a Parkinson's patient.

1. Introduction

The Elsevier cas-dc class is based on the standard article class and supports almost all of the functionality of that class. In addition, it features commands and options to format the

- document style
- baselineskip
- front matter
- keywords and MSC codes
- theorems, definitions and proofs
- lables of enumerations
- citation style and labeling.

This class depends on the following packages for its proper functioning:

1. natbib.sty for citation processing;
2. geometry.sty for margin settings;
3. fleqn.clo for left aligned equations;
4. graphicx.sty for graphics inclusion;
5. hyperref.sty optional packages if hyperlinking is required in the document;

All the above packages are part of any standard LaTeX installation. Therefore, the users need not be bothered about downloading any extra packages.

*Corresponding author
mazlaghani@aut.ac.ir (M. Amirmazlaghani); amin-amini@aut.ac.ir (A. Amini)
ORCID(s):

2. Installation

The package is available at author resources page at Elsevier (http://www.elsevier.com/locate/latex). The class may be moved or copied to a place, usually, $TEXMF/tex/latex/elsevier/, or a folder which will be read by LaTeX during document compilation. The TeX file database needs updation after moving/copying class file. Usually, we use commands like mktexlsr or texhash depending upon the distribution and operating system.

3. Front matter

The author names and affiliations could be formatted in two ways:

(1) Group the authors per affiliation.
(2) Use footnotes to indicate the affiliations.

See the front matter of this document for examples. You are recommended to conform your choice to the journal you are submitting to.

4. Bibliography styles

There are various bibliography styles available. You can select the style of your choice in the preamble of this document. These styles are Elsevier styles based on standard styles like Harvard and Vancouver. Please use BibTeX to generate your bibliography and include DOIs whenever available.

Here are two sample references: [1] [8, 7] [9, 6, 2, 3, 4, 10, 5]

5. Floats

Figures may be included using the command, `\includegraphics` in combination with or without its several options to further control graphic. `\includegraphics` is provided by graphic[s,x].sty which is part of any standard LaTeX distribution. graphicx.sty is loaded by default. LaTeX accepts figures in the postscript format while pdfLaTeX accepts *.pdf, *.mps (metapost), *.jpg and *.png formats. pdfLaTeX does not accept graphic files in the postscript format.

The `table` environment is handy for marking up tabular material. If users want to use multirow.sty, array.sty, etc., to fine control/enhance the tables, they are welcome to load any package of their choice and cas-dc.cls will work in combination with all loaded packages.

Table 1
This is a test caption. This is a test caption. This is a test caption. This is a test caption.

Col 1	Col 2	Col 3	Col4
12345	12345	123	12345
12345	12345	123	12345
12345	12345	123	12345
12345	12345	123	12345
12345	12345	123	12345

6. Theorem and theorem like environments

cas-dc.cls provides a few shortcuts to format theorems and theorem-like environments with ease. In all commands the options that are used with the `\newtheorem` command will work exactly in the same manner. cas-dc.cls provides three commands to format theorem or theorem-like environments:

```
\newtheorem{theorem}{Theorem}
\newtheorem{lemma}[theorem]{Lemma}
\newdefinition{rmk}{Remark}
\newproof{pf}{Proof}
\newproof{pot}{Proof of Theorem \ref{thm2}}
```

The `\newtheorem` command formats a theorem in LaTeX's default style with italicized font, bold font for theorem heading and theorem number at the right hand side of the theorem heading. It also optionally accepts an argument which will be printed as an extra heading in parentheses.

```
\begin{theorem}
 For system (8), consensus can be achieved with
 $\|T_{\omega z}$ ...
   \begin{eqnarray}\label{10}
   ....
   \end{eqnarray}
\end{theorem}
```

Theorem 1. *For system (8), consensus can be achieved with* $\|T_{\omega z}$ ...

.... (1)

The `\newdefinition` command is the same in all respects as its `\newtheorem` counterpart except that the font shape is roman instead of italic. Both `\newdefinition` and `\newtheorem` commands automatically define counters for the environments defined.

The `\newproof` command defines proof environments with upright font shape. No counters are defined.

7. Enumerated and Itemized Lists

cas-dc.cls provides an extended list processing macros which makes the usage a bit more user friendly than the default LaTeX list macros. With an optional argument to the `\begin{enumerate}` command, you can change the list counter type and its attributes.

```
\begin{enumerate}[1.]
\item The enumerate environment starts with an optional
 argument `1.', so that the item counter will be suffixed
  by a period.
\item You can use `a)' for alphabetical counter and '(i)'
 for roman counter.
 \begin{enumerate}[a)]
  \item Another level of list with alphabetical counter.
   \item One more item before we start another.
   \item One more item before we start another.
   \item One more item before we start another.
   \item One more item before we start another.
```

Further, the enhanced list environment allows one to prefix a string like 'step' to all the item numbers.

```
\begin{enumerate}[Step 1.]
 \item This is the first step of the example list.
 \item Obviously this is the second step.
 \item The final step to wind up this example.
\end{enumerate}
```

8. Cross-references

In electronic publications, articles may be internally hyperlinked. Hyperlinks are generated from proper cross-references in the article. For example, the words Fig. 1 will never be more than simple text, whereas the proper cross-reference `\ref{tiger}` may be turned into a hyperlink to the figure itself: Fig. 1. In the same way, the words Ref. [1] will fail to turn into a hyperlink; the proper cross-reference is `\cite{Knuth96}`. Cross-referencing is possible in LaTeX for sections, subsections, formulae, figures, tables, and literature references.

9. Bibliography

Two bibliographic style files (`*.bst`) are provided — model1-num-names.bst and model2-names.bst — the first one can be used for the numbered scheme. This can also be used for the numbered with new options of natbib.sty. The second one is for the author year scheme. When you use model2-names.bst, the citation commands will be like `\citep`, `\citet`,

\citealt etc. However when you use model1-num-names.bst, you may use only \cite command.

thebibliography environment. Each reference is a \bibitem and each \bibitem is identified by a label, by which it can be cited in the text:
In connection with cross-referencing and possible future hyperlinking it is not a good idea to collect more that one literature item in one \bibitem. The so-called Harvard or author-year style of referencing is enabled by the LaTeX package natbib. With this package the literature can be cited as follows:

- Parenthetical: \citep{WB96} produces (Wettig & Brown, 1996).
- Textual: \citet{ESG96} produces Elson et al. (1996).
- An affix and part of a reference: \citep[e.g.][Ch. 2]{Gea97} produces (e.g. Governato et al., 1997, Ch. 2).

In the numbered scheme of citation, \cite{<label>} is used, since \citep or \citet has no relevance in the numbered scheme. natbib package is loaded by cas-dc with numbers as default option. You can change this to author-year or harvard scheme by adding option authoryear in the class loading command. If you want to use more options of the natbib package, you can do so with the \biboptions command. For details of various options of the natbib package, please take a look at the natbib documentation, which is part of any standard LaTeX installation.

A. My Appendix

Appendix sections are coded under \appendix.

\printcredits command is used after appendix sections to list author credit taxonomy contribution roles tagged using \credit in frontmatter.

CRediT authorship contribution statement

Amin Amini: Conceptualization of this study, Methodology, Software.

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