Procesamiento de voz para mejorar la pronunciación

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Resumen

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Keywords: Procesamiento de señales, detección de blobs, . . .

Abstract

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Keywords: Procesamiento de señales, detección de blobs, ...

Acknowledgements

Under construction

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Lista de Abreviaturas

DSP	**D**igital **S**ignal **P**rocessing
FIR	**F**inite **I**mpulse **R**esponse
IIR	**I**nfinite **I**mpulse **R**esponse

Capítulo 1

Chapter Title Here

1.1 Welcome and Thank You

Welcome to this LaTeX Thesis Template, a beautiful and easy to use template for writing a thesis using the LaTeX typesetting system.

If you are writing a thesis (or will be in the future) and its subject is technical or mathematical (though it doesn't have to be), then creating it in LaTeX is highly recommended as a way to make sure you can just get down to the essential writing without having to worry over formatting or wasting time arguing with your word processor.

LaTeX is easily able to professionally typeset documents that run to hundreds or thousands of pages long. With simple mark-up commands, it automatically sets out the table of contents, margins, page headers and footers and keeps the formatting consistent and beautiful. One of its main strengths is the way it can easily typeset mathematics, even *heavy* mathematics. Even if those equations are the most horribly twisted and most difficult mathematical problems that can only be solved on a super-computer, you can at least count on LaTeX to make them look stunning.

1.2 Learning LaTeX

LaTeX is not a WYSIWYG (What You See is What You Get) program, unlike word processors such as Microsoft Word or Apple's Pages. Instead, a document written for LaTeX is actually a simple, plain text file that contains *no formatting*. You tell LaTeX how you want the formatting in the finished document by writing in simple commands amongst the text, for example, if I want to use *italic text for emphasis*, I write the `\emph{text}` command and put the text I want in italics in between the curly braces. This means that LaTeX is a mark-up language, very much like HTML.

1.2.1 A (not so short) Introduction to LaTeX

If you are new to LaTeX, there is a very good eBook – freely available online as a PDF file – called, The Not So Short Introduction to LaTeX. The book's title is typically shortened to just *lshort*. You can download the latest version (as it is occasionally updated) from here: http://www.ctan.org/tex-archive/info/lshort/english/lshort.pdf

It is also available in several other languages. Find yours from the list on this page: http://www.ctan.org/tex-archive/info/lshort/

It is recommended to take a little time out to learn how to use LaTeX by creating several, small 'test' documents, or having a close look at several templates on: http://www.LaTeXTemplates.com

Making the effort now means you're not stuck learning the system when what you *really* need to be doing is writing your thesis.

1.2.2 A Short Math Guide for LaTeX

If you are writing a technical or mathematical thesis, then you may want to read the document by the AMS (American Mathematical Society) called, A Short Math Guide for LaTeX. It can be found online here: http://www.ams.org/tex/amslatex.html under the Additional Documentation section towards the bottom of the page.

1.2.3 Common LaTeX Math Symbols

There are a multitude of mathematical symbols available for LaTeX and it would take a great effort to learn the commands for them all. The most common ones you are likely to use are shown on this page: http://www.sunilpatel.co.uk/latex-type/latex-math-symbols/

You can use this page as a reference or crib sheet, the symbols are rendered as large, high quality images so you can quickly find the LaTeX command for the symbol you need.

1.2.4 LaTeX on a Mac

The LaTeX distribution is available for many systems including Windows, Linux and Mac OS X. The package for OS X is called MacTeX and it contains all the applications you need – bundled together and pre-customized – for a fully working LaTeX environment and work flow.

MacTeX includes a custom dedicated LaTeX editor called TeXShop for writing your '**`.tex`**' files and BibDesk: a program to manage your references and create your bibliography section just as easily as managing songs and creating playlists in iTunes.

1.3 Getting Started with this Template

If you are familiar with LaTeX, then you should explore the directory structure of the template and then proceed to place your own information into the *THESIS INFORMATION* block of the **`main.tex`** file. You can then modify the rest of this file to your unique specifications based on your degree/university. Section 1.5 on page 4 will help you do this. Make sure you also read section 1.7 about thesis conventions to get the most out of this template.

If you are new to LaTeX it is recommended that you carry on reading through the rest of the information in this document.

Before you begin using this template you should ensure that its style complies with the thesis style guidelines imposed by your institution. In most cases this template style and layout will be suitable. If it is not, it may only require a small change to bring the template in line with your institution's recommendations. These modifications will need to be done on the **`MastersDoctoralThesis.cls`** file.

1.3.1 About this Template

This LaTeX Thesis Template is originally based and created around a LaTeX style file created by Steve R. Gunn from the University of Southampton (UK), department of Electronics and Computer Science. You can find his original thesis style file at his site, here: http://www.ecs.soton.ac.uk/~srg/softwaretools/document/templates/

Steve's **ecsthesis.cls** was then taken by Sunil Patel who modified it by creating a skeleton framework and folder structure to place the thesis files in. The resulting template can be found on Sunil's site here: http://www.sunilpatel.co.uk/thesis-template

Sunil's template was made available through http://www.LaTeXTemplates.com where it was modified many times based on user requests and questions. Version 2.0 and onwards of this template represents a major modification to Sunil's template and is, in fact, hardly recognisable. The work to make version 2.0 possible was carried out by Vel and Johannes Böttcher.

1.4 What this Template Includes

1.4.1 Folders

This template comes as a single zip file that expands out to several files and folders. The folder names are mostly self-explanatory:

Appendices – this is the folder where you put the appendices. Each appendix should go into its own separate **.tex** file. An example and template are included in the directory.

Chapters – this is the folder where you put the thesis chapters. A thesis usually has about six chapters, though there is no hard rule on this. Each chapter should go in its own separate **.tex** file and they can be split as:

- Chapter 1: Introduction to the thesis topic
- Chapter 2: Background information and theory
- Chapter 3: (Laboratory) experimental setup
- Chapter 4: Details of experiment 1
- Chapter 5: Details of experiment 2
- Chapter 6: Discussion of the experimental results
- Chapter 7: Conclusion and future directions

This chapter layout is specialised for the experimental sciences, your discipline may be different.

Figures – this folder contains all figures for the thesis. These are the final images that will go into the thesis document.

1.4.2 Files

Included are also several files, most of them are plain text and you can see their contents in a text editor. After initial compilation, you will see that more auxiliary files are created by LaTeX or BibTeX and which you don't need to delete or worry about:

example.bib – this is an important file that contains all the bibliographic information and references that you will be citing in the thesis for use with BibTeX. You can write it manually, but there are reference manager programs available that will create and manage it for you. Bibliographies in LaTeX are a large subject and you may need to read about BibTeX before starting with this. Many modern reference managers will allow you to export your references in BibTeX format which greatly eases the amount of work you have to do.

MastersDoctoralThesis.cls – this is an important file. It is the class file that tells LaTeX how to format the thesis.

main.pdf – this is your beautifully typeset thesis (in the PDF file format) created by LaTeX. It is supplied in the PDF with the template and after you compile the template you should get an identical version.

main.tex – this is an important file. This is the file that you tell LaTeX to compile to produce your thesis as a PDF file. It contains the framework and constructs that tell LaTeX how to layout the thesis. It is heavily commented so you can read exactly what each line of code does and why it is there. After you put your own information into the *THESIS INFORMATION* block – you have now started your thesis!

Files that are *not* included, but are created by LaTeX as auxiliary files include:

main.aux – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file.

main.bbl – this is an auxiliary file generated by BibTeX, if it is deleted, BibTeX simply regenerates it when you run the `main.aux` file. Whereas the `.bib` file contains all the references you have, this `.bbl` file contains the references you have actually cited in the thesis and is used to build the bibliography section of the thesis.

main.blg – this is an auxiliary file generated by BibTeX, if it is deleted BibTeX simply regenerates it when you run the main `.aux` file.

main.lof – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It tells LaTeX how to build the *List of Figures* section.

main.log – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It contains messages from LaTeX, if you receive errors and warnings from LaTeX, they will be in this `.log` file.

main.lot – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file. It tells LaTeX how to build the *List of Tables* section.

main.out – this is an auxiliary file generated by LaTeX, if it is deleted LaTeX simply regenerates it when you run the main `.tex` file.

So from this long list, only the files with the `.bib`, `.cls` and `.tex` extensions are the most important ones. The other auxiliary files can be ignored or deleted as LaTeX and BibTeX will regenerate them.

1.5 Filling in Your Information in the `main.tex` File

You will need to personalise the thesis template and make it your own by filling in your own information. This is done by editing the `main.tex` file in a text editor or your favourite LaTeX environment.

Open the file and scroll down to the third large block titled *THESIS INFORMATION* where you can see the entries for *University Name*, *Department Name*, etc …

Fill out the information about yourself, your group and institution. You can also insert web links, if you do, make sure you use the full URL, including the `http://` for this. If you don't want these to be linked, simply remove the `\href{url}{name}` and only leave the name.

When you have done this, save the file and recompile `main.tex`. All the information you filled in should now be in the PDF, complete with web links. You can now begin your thesis proper!

1.6 The `main.tex` File Explained

The **`main.tex`** file contains the structure of the thesis. There are plenty of written comments that explain what pages, sections and formatting the LaTeX code is creating. Each major document element is divided into commented blocks with titles in all capitals to make it obvious what the following bit of code is doing. Initially there seems to be a lot of LaTeX code, but this is all formatting, and it has all been taken care of so you don't have to do it.

Begin by checking that your information on the title page is correct. For the thesis declaration, your institution may insist on something different than the text given. If this is the case, just replace what you see with what is required in the *DECLARATION PAGE* block.

Then comes a page which contains a funny quote. You can put your own, or quote your favourite scientist, author, person, and so on. Make sure to put the name of the person who you took the quote from.

Following this is the abstract page which summarises your work in a condensed way and can almost be used as a standalone document to describe what you have done. The text you write will cause the heading to move up so don't worry about running out of space.

Next come the acknowledgements. On this page, write about all the people who you wish to thank (not forgetting parents, partners and your advisor/supervisor).

The contents pages, list of figures and tables are all taken care of for you and do not need to be manually created or edited. The next set of pages are more likely to be optional and can be deleted since they are for a more technical thesis: insert a list of abbreviations you have used in the thesis, then a list of the physical constants and numbers you refer to and finally, a list of mathematical symbols used in any formulae. Making the effort to fill these tables means the reader has a one-stop place to refer to instead of searching the internet and references to try and find out what you meant by certain abbreviations or symbols.

The list of symbols is split into the Roman and Greek alphabets. Whereas the abbreviations and symbols ought to be listed in alphabetical order (and this is *not* done automatically for you) the list of physical constants should be grouped into similar themes.

The next page contains a one line dedication. Who will you dedicate your thesis to?

Finally, there is the block where the chapters are included. Uncomment the lines (delete the `%` character) as you write the chapters. Each chapter should be written in its own file and put into the *Chapters* folder and named **`Chapter1`**, **`Chapter2`**, etc... Similarly for the appendices, uncomment the lines as you need them. Each appendix should go into its own file and placed in the *Appendices* folder.

After the preamble, chapters and appendices finally comes the bibliography. The bibliography style (called *`authoryear`*) is used for the bibliography and is a fully featured style that will even include links to where the referenced paper can be found online. Do not underestimate how grateful your reader will be to find that a reference to a paper is just a click away. Of course, this relies on you putting the URL information into the BibTeX file in the first place.

1.7 Thesis Features and Conventions

To get the best out of this template, there are a few conventions that you may want to follow.

One of the most important (and most difficult) things to keep track of in such a long document as a thesis is consistency. Using certain conventions and ways of doing things (such as using a Todo list) makes the job easier. Of course, all of these are optional and you can adopt your own method.

1.7.1 Printing Format

This thesis template is designed for double sided printing (i.e. content on the front and back of pages) as most theses are printed and bound this way. Switching to one sided printing is as simple as uncommenting the *`oneside`* option of the `documentclass` command at the top of the **`main.tex`** file. You may then wish to adjust the margins to suit specifications from your institution.

The headers for the pages contain the page number on the outer side (so it is easy to flick through to the page you want) and the chapter name on the inner side.

The text is set to 11 point by default with single line spacing, again, you can tune the text size and spacing should you want or need to using the options at the very start of **`main.tex`**. The spacing can be changed similarly by replacing the *`singlespacing`* with *`onehalfspacing`* or *`doublespacing`*.

1.7.2 Using US Letter Paper

The paper size used in the template is A4, which is the standard size in Europe. If you are using this thesis template elsewhere and particularly in the United States, then you may have to change the A4 paper size to the US Letter size. This can be done in the margins settings section in **`main.tex`**.

Due to the differences in the paper size, the resulting margins may be different to what you like or require (as it is common for institutions to dictate certain margin sizes). If this is the case, then the margin sizes can be tweaked by modifying the values in the same block as where you set the paper size. Now your document should be set up for US Letter paper size with suitable margins.

1.7.3 Tables

Tables are an important way of displaying your results, below is an example table which was generated with this code:

```
\begin{table}
\caption{The effects of treatments X and Y on the four groups studied.}
\label{tab:treatments}
\centering
\begin{tabular}{l l l}
\toprule
\tabhead{Groups} & \tabhead{Treatment X} & \tabhead{Treatment Y} \\
```

TABLA 1.1: The effects of treatments X and Y on the four groups studied.

Groups	Treatment X	Treatment Y
1	0.2	0.8
2	0.17	0.7
3	0.24	0.75
4	0.68	0.3

```
\midrule
1 & 0.2 & 0.8\\
2 & 0.17 & 0.7\\
3 & 0.24 & 0.75\\
4 & 0.68 & 0.3\\
\bottomrule\\
\end{tabular}
\end{table}
```

You can reference tables with `\ref{<label>}` where the label is defined within the table environment. See **`Chapter1.tex`** for an example of the label and citation (e.g. Table 1.1).

1.7.4 Figures

There will hopefully be many figures in your thesis (that should be placed in the *Figures* folder). The way to insert figures into your thesis is to use a code template like this:

```
\begin{figure}
\centering
\includegraphics{Figures/Electron}
\decoRule
\caption[An Electron]{An electron (artist's impression).}
\label{fig:Electron}
\end{figure}
```

Also look in the source file. Putting this code into the source file produces the picture of the electron that you can see in the figure below.

Sometimes figures don't always appear where you write them in the source. The placement depends on how much space there is on the page for the figure. Sometimes there is not enough room to fit a figure directly where it should go (in relation to the text) and so LaTeX puts it at the top of the next page. Positioning figures is the job of LaTeX and so you should only worry about making them look good!

Figures usually should have captions just in case you need to refer to them (such as in Figure 1.1). The `\caption` command contains two parts, the first part, inside the square brackets is the title that will appear in the *List of Figures*, and so should be short. The second part in the curly brackets should contain the longer and more descriptive caption text.

The `\decoRule` command is optional and simply puts an aesthetic horizontal line below the image. If you do this for one image, do it for all of them.

LaTeX is capable of using images in pdf, jpg and png format.

FIGURA 1.1: An electron (artist's impression).

1.7.5 Typesetting mathematics

If your thesis is going to contain heavy mathematical content, be sure that LaTeX will make it look beautiful, even though it won't be able to solve the equations for you.

The Not So Short Introduction to LaTeX (available on CTAN) should tell you everything you need to know for most cases of typesetting mathematics. If you need more information, a much more thorough mathematical guide is available from the AMS called, A Short Math Guide to LaTeX and can be downloaded from: ftp://ftp.ams.org/pub/tex/doc/amsmath/short-math-guide.pdf

There are many different LaTeX symbols to remember, luckily you can find the most common symbols in The Comprehensive LaTeX Symbol List.

You can write an equation, which is automatically given an equation number by LaTeX like this:

```
\begin{equation}
E = mc^{2}
\label{eqn:Einstein}
\end{equation}
```

This will produce Einstein's famous energy-matter equivalence equation:

$$E = mc^2 \tag{1.1}$$

All equations you write (which are not in the middle of paragraph text) are automatically given equation numbers by LaTeX. If you don't want a particular equation numbered, use the unnumbered form:

```
\[ a^{2}=4 \]
```

1.8 Sectioning and Subsectioning

You should break your thesis up into nice, bite-sized sections and subsections. LaTeX automatically builds a table of Contents by looking at all the `\chapter{}`, `\section{}` and `\subsection{}` commands you write in the source.

The Table of Contents should only list the sections to three (3) levels. A `chapter{}` is level zero (0). A `\section{}` is level one (1) and so a `\subsection{}` is level two (2). In your thesis it is likely that you will even use a `subsubsection{}`, which is level three (3). The depth to which the Table of Contents is formatted is set within **`MastersDoctoralThesis.cls`**. If you need this changed, you can do it in **`main.tex`**.

1.9 In Closing

You have reached the end of this mini-guide. You can now rename or overwrite this pdf file and begin writing your own **`Chapter1.tex`** and the rest of your thesis. The easy work of setting up the structure and framework has been taken care of for you. It's now your job to fill it out!

Good luck and have lots of fun!

Guide written by —
Sunil Patel: www.sunilpatel.co.uk
Vel: LaTeXTemplates.com

Capítulo 2

Introducción

2.1 Motivación

Section UNDER CONSTRUCTION Lorem ipsum dolor sit amet, consectetur adipiscing elit.[1]

2.1.1 Subsection 1

Subsection UNDER CONSTRUCTION posuere quam at lectus tristique eu ultrices augue venenatis. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae.

2.2 Objetivos

Section UNDER CONSTRUCTION Sed ullamcorper quam eu nisl interdum at interdum enim egestas. Aliquam placerat justo sed lectus lobortis ut porta nisl porttitor.

2.3 Fundamentos

Section UNDER CONSTRUCTION Wosuere quam at lectus tristique eu ultrices augue venenatis. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae

2.4 Estructura de la memoria

Section UNDER CONSTRUCTION Fosuere quam at lectus tristique eu ultrices augue venenatis. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae

Capítulo 3

Diseño e implementación

En esta sección explicaremos detenidamente los distintos pasos que se llevaron a cabo para obtener la aplicación final.

Como se ha indicado en la introducción, la tarea fundamental de nuestra aplicación consiste en procesar lo que diga el usuario para poder comparar su pronunciación con la de un nativo. La aplicación está enfocada al tratamiento y comparación del sonido y puede ser incluida por cualquier otra aplicación con interfaz de usuario, ya sea una aplicación móvil, de escritorio u online. Teniendo esto en cuenta se diseñó la aplicación.

Una de las decisiones fue programar en lenguaje Java ya que es con el que tengo más dominio y experiencia. Además, Java tiene muchas bibliotecas y recursos que hemos tratado de aprovechar. El código puede encontrarse REF [1] y es código abierto y libre. La estructura del código de la aplicación se puede encontrar en esta memoria. REF [1]

REVISAR porque tiene que tener sentido con que al principio era android

Daremos en primer lugar una visión general de todo el programa. Cuando una persona use el programa se grabará diciendo una frase indicada y la aplicación dirá si la pronunciación ha sido suficientemente buena y leal a la de un nativo. Por ello, el primer paso es obtener un audio directamente del micrófono del medio que esté usando el usuario. El sonido capturado se guardará digitalmente como una secuencia de intensidades que contienen toda la información de audio, este contiene muchas frecuencias no útiles para nuestro objetivo de comparar voces pronunciando la misma frase. Por ello habrá una etapa de filtrado. Después se hará una transformación de Fourier a la señal dividida en segmentos, que nos dará el valor de los impulsos por frecuencia de los segmentos. Aprovecharemos que se encuentra en el dominio de la frecuencia para quitar el sonido de fondo. Y con el espectrograma resultante de la transformación limpia nos quedaremos con la matriz bidimensional asociada, donde cada valor representa la intensidad del impulso por tiempo (segmento) y frecuencia. Esta matriz se puede interpretar como una imagen donde el color en cada punto se consigue a partir del elemento correspondiente en la matriz. Una vez que tenemos la imagen, se hace una detección de blobs o regiones para distinguir las zonas más destacables o sobresalientes de la imagen. Con esto conseguiremos una matriz de valores con más contraste y lista para ser comparada con otra matriz de la misma clase, teniendo en cuenta que las dimensiones de las matrices pueden variar ya sea por la velocidad o volumen del hablante.

En el resto de la sección daremos los detalles de estos pasos, dando en primer lugar una explicación teórica y desarrollando después los principales aspectos de implementación.

3.1 Capturando la voz

Cuando el usuario grabe su voz para ser procesada debemos capturar el audio en un formato que nos facilite su tratamiento. Grabar en formato de audio *raw* nos da total control y visualización de los datos capturados. Cuando emitimos el sonido para ser grabado emitimos una señal analógica (continua) que el micrófono captura y guarda en forma de señal digital (discreta). La transformación de esta señal analógica a digital se hace a través de un proceso llamado muestreo. En procesamiento de señales, el muestreo es la reducción de una señal continua a una señal discreta. Consiste en tomar muestras de una señal analógica a una frecuencia o tasa de muestreo (*sample rate*) constante, para cuantificarlas y codificarlas posteriormente. La cuantificación consiste en atribuir un valor finito (discreto) de amplitud a cada muestra, un valor dentro de un conjunto específico de valores que luego es codificado en bits.

En la figura 3.1 podemos observar cómo se toman muestras discretas S_i de la señal continua $S(t)$ cada T unidades de tiempo.

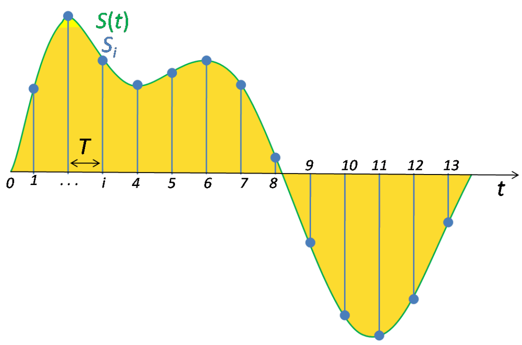

FIGURA 3.1: Muestreo de una señal continua para obtener una señal discreta.

Por tanto, el sonido se graba en muestras discretas y la velocidad con la que se toman estas muestras se llama *sample rate* o frecuencia de muestreo.

El método más común de representar sonido analógico digitalmente modulación por impulsos codificados (PCM por sus siglas en inglés *Pulse-code modulation*[1]).

lta referencia

PCM es un procedimiento de modulación que transforma una señal analógica en una secuencia de bits. Además, es la forma estándar de audio digital en ordenadores, discos compactos, telefonía digital y otras aplicaciones similares. [1]

En un flujo PCM la intensidad de una señal analógica es muestreada regularmente en intervalos uniformes, y cada muestra es cuantizada al valor más cercano dentro de un rango de pasos digitales.

Para determinar cómo será la señal digital y medir su fidelidad a la señal analógica, el flujo PCM tiene dos propiedades básicas:

- Frecuencia de muestreo: el número de veces por segundo que se toma una muestra
- *Bit depth*: el número de posibles valores digitales usados para representar cada muestra.

¿Qué valores le daremos a estas variables?

En cuanto a la frecuencia de muestreo, hay que tener en cuenta los límites de audición o rango de frecuencias que un humano percibe, que se encuentran entre los 20 y 20K Hz. Por esto, en música y grabaciones en general se muestrea a 44.1 kHz, es decir, se toman 44.1 mil muestras de la señal analógica por segundo.

Por otro lado, las señales de voz o *speech*, que solo contienen la voz humana, se suelen tomar menos muestras por segundo. La mayoría de fonemas se encuentra entre 100 y 4K Hz, permitiendo un *sample rate* de 8 kHz. [1].

Usaremos un ratio de 44.1 kHz por ser más común y bastante utilizado. Pero tendremos en cuenta más adelante el rango de frecuencias en que se mueve la señal de la voz.

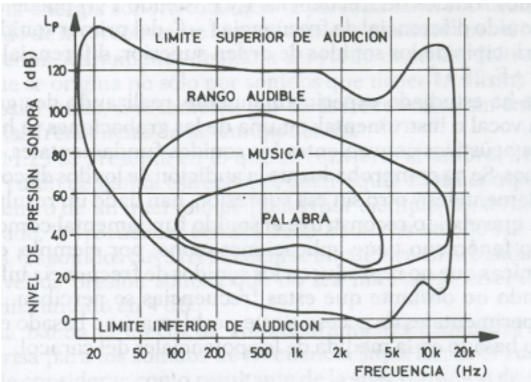

FIGURA 3.2: Límites de audición humanos.

Para explicar por qué se escoge como frecuencia el doble del máximo valor del rango usaremos el teorema de muestreo de Nyquist-Shannon, que dice que al tomar muestras de una señal con una frecuencia que sea el doble de la frecuencia máxima de la señal, dichas muestras contendrán toda la información necesaria para reconstruir la señal original. Es decir, se podrá reconstruir la señal analógica a partir de la digital. Y por eso siempre se toma ese criterio para elegir la frecuencia de muestreo.

Y en cuanto al *bit depth*, es decir, el número de bits de información para cada muestra que se corresponde directamente con el valor cuantificado de la muestra, elegiremos uno común. Los *bit depth* más comunes para PCM son 8, 16, 20 o 24 bits por muestra. Nosotros usaremos un *short* con signo que son 16 bits. Un *bit depth* de 16-bit nos dará 65536 niveles.

Otra variable que debemos configurar cuando grabamos audio es el número de canales, en este caso un solo canal o monocanal será suficiente, no necesitamos más. Un canal de audio es un canal o pista donde los elementos grabados tienen su propio área en la grabación, cuando escuchamos una grabación con varios canales, todos ellos suenan simultáneamente. Cuando se almacena música se usan dos canales (estéreo) y más de dos en el caso de películas para conseguir un mejor efecto.

En cuanto al formato del archivo de audio que obtenemos, como hemos dicho, intentaremos que sea formato *raw* o PCM, es decir, una secuencia de palabras de 16 bits que representan la intensidad de cada muestra tomada de la señal.

En cuanto a la implementación, dos de los formatos contenedores de audio más conocidos, WAV y AIFF, utilizan el formato PCM. Nosotros utilizaremos WAVE (*Waveform Audio File Format*) conocido como WAV, que es en pocas palabras, un *raw* con cabecera donde se tiene el tamaño del archivo, el tamaño de la cabecera, el formato de audio (PCM), la frecuencia de muestreo, número de canales (1 o 2 ya que WAV es solo para audio digital), el número de bits por muestra y otros campos como se muestra en la imagen 3.3. Quitar esa cabecera y obtener los datos en crudo es muy simple: tan solo debemos descartar los primeros 44 bits y guardamos el resultado en un **`.raw`**. Nos quedamos con lo que llama `data` que es el audio en bruto y se encuentra codificado con sistema *little-endian*, esto quiere decir que el byte más significativo de los dos que forman las palabras de 16 bits es el segundo y, por tanto, se almacena en primer lugar.

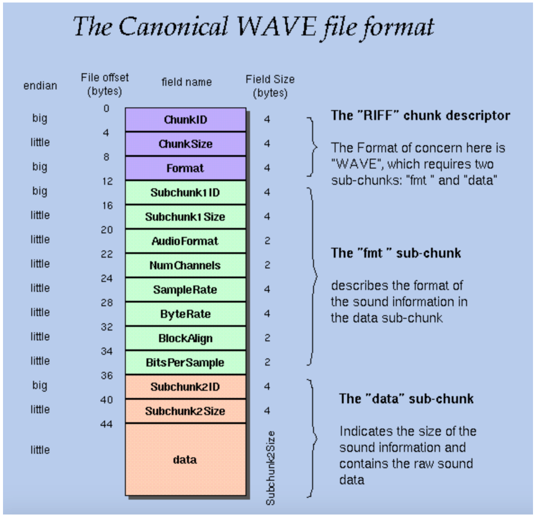

FIGURA 3.3: Formato de archivos WAVE

En resumen los ajustes que usaremos para capturar audio en formato WAV serán los siguientes:

- Codificación 16-bit PCM.
- Un solo canal o monocanal.
- Frecuencia de muestreo: 44.1 kHz
- Sistema *little-endian* para almacenar los bytes.

En nuestro caso, hemos llevado a cabo esta captura de voz con la aplicación de captura y edición de audio Audacity [1] , que es software libre y multiplataforma. En Audacity puedes especificar las configuraciones que indicamos en la descripción teórica que hemos presentado anteriormente; al leer un fichero raw será necesario indicar estos ajustes.

La forma de obtener el archivo de audio wav o raw es abierta. Usar Audacity es lo que nosotros hemos hecho pero se pueden obtener de muchas otras formas. Por ejemplo, un dato interesante es que todo dispositivo Android soporta la captura de audio con 1 canal a 44.1 kHz en codificación 16-bit PCM.

Ya tenemos hecho el primer paso, hemos conseguido los datos de audio en un formato que podemos manipular. El audio grabado está en bruto, lo siguiente será quitarle el ruido y frecuencias no útiles.

3.1.1 Subsection 1

Nunc posuere quam at l

Apéndice A

Frequently Asked Questions

A.1 How do I change the colors of links?

The color of links can be changed to your liking using:
`\hypersetup{urlcolor=red}`, or
`\hypersetup{citecolor=green}`, or
`\hypersetup{allcolor=blue}`.
If you want to completely hide the links, you can use:
`\hypersetup{allcolors=.}`, or even better:
`\hypersetup{hidelinks}`.
If you want to have obvious links in the PDF but not the printed text, use:
`\hypersetup{colorlinks=false}`. The color of links can be changed to your liking using:
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Bibliografía

[1] poner referencia

[2] Leslie Lamport, *LaTeX: a document preparation system*, Addison Wesley, Massachusetts, 2nd edition, 1994.