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| *Predictive modelling of sea debris around Maltese coastal waters* |
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Abstract

The accumulation of sea surface debris around the coastal waters of Malta, presents numerous ecological and environmental challenges that negatively affect both marine ecosystems and human activities. This is exacerbated by the absence of an effective system that can predict their movement, making it more challenging to address and mitigate this issue effectively.

The primary objective of this project was to develop a system that can predict dispersion patterns of sea surface debris around Malta’s coast. To achieve this, we developed a comprehensive machine learning and physics-based pipeline. This pipeline uses historical sea surface current data to predict future conditions, while also having the ability to visualise the movement of debris.

Central to this system is the integration of LSTM and GRU models, trained to predict the next 24 hours of sea currents within a specific area. These predictions were subsequently utilised by the Lagrangian model to visualise the movement of surface debris, offering insights into future dispersion patterns.

A comparative evaluation was conducted for both models, examining the accuracy of their predictions and the quality of the simulations generated by the Lagrangian model, based on these predictions. The results indicated that the LSTM model outperformed the GRU model. This was evidenced by the LSTM's enhanced precision in forecasting the movements of sea surface currents, thereby providing a more reliable basis for the subsequent simulation of debris dispersal patterns.

Overall, this project offers a novel approach to addressing the challenge of seasurface debris around Malta. By harnessing the power of machine learning in tandem with a physics based Lagrangian model, we have established a framework that not only predicts sea surface currents with notable accuracy, but also visualises the movement of surfacemarine debris, allowing us to make more informed decisions about our environment and our effect on it.

Acknowledgements

I would like to extend my deepest gratitude to several individuals whose support and guidance were invaluable in the completion of this project.

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List of Abbreviations

FYP Final year project (Style: Abbreviations)

Note that the List of Abbreviations should be sorted on the acronym list.

The entries in the List of Abbreviations should be assigned the Abbreviations style.

# Introduction

This project is an integration of machine learning techniques with a physics based Lagrangian model to address the environmental issues of sea debris. At the core of this project is a pipeline that harnesses historical data to forecast future conditions, specifically predicting the next 24 hours of sea surface currents. These predictions serve as inputs for a Lagrangian model [1], enabling it to simulate the movement of marine debris. Finally, a comparative evaluation of both LSTM and GRU models is conducted, focusing on their predictive accuracy and the quality of the visualizations. This project demonstrates a novel approach of combining machine learning with a physics-based model, while also contributing valuable insights into enhancing marine conservation efforts, leading to more informed decision-making regarding marine debris management.

## Problem Definition

Sea surface debris around the coastal waters of Malta presents a significant environmental challenge. Predominantly composed of plastics, which constitute 82% of all man-made floating items encountered in the Mediterranean sea [2], this debris endangers marine life, disrupts ecological balances, and undermines the ecological integrity of coastal areas [3]. This problem is further aggravated by the lack of an effective system that can predict and forecast the movement of this surface debris, since as of writing, there exists no system that adequately addresses this challenge specifically for the coastal areas around Malta. This further underscores the need for a system that can predict and visualise the dispersion patterns of sea surface debris.

## Motivation

The geological characteristics of the Mediterranean sea makes it difficult for surface debris to escape the area naturally, leading to the accumulation of sea surface debris [4]. The current absence of a predictive system tailored to the coastal region of Malta impedes effective interventions to mitigate environmental harm. This gap opens an opportunity for the implementation of a system that through the application of Machine Learning and physics-based modelling, aims to address an urgent ecological issue. By fulfilling this need, the project aims to provide accurate predictions that can guide effective cleanup operations and inform strategies for long-term marine conservation around the surrounding waters of Malta.

## Aims and Objectives

The aim of this project is to create a system enhanced with Machine Learning for simulating and predicting the movement of marine debris in the coastal waters of Malta, thereby supporting marine conservation efforts. To achieve this aim, the following objectives have been identified:

1. Data integration: To preprocess and integrate the sea surface currents datasets ensuring compatibility and consistency for input into both models.
2. Lagrangian model development: To utilize the Ocean Parcels Python toolkit for simulating the movement of surface marine debris, employing historical data to ensure accurate simulations.
3. AI models development: To develop and fine-tune both LSTM and GRU models for the prediction of future sea surface currents. These models will serve as a crucial component of the forecasting system, leveraging their respective strengths in sequence data processing to ensure robust and accurate predictions.
4. Integrating the AI models with the Lagrangian model: To integrate the model’s predictions into the Lagrangian model. This integration aims to create future simulations and visualisations of marine debris movement, enhancing the project’s predictive capabilities for marine conservation.
5. Comparison of AI models: To conduct a comparative evaluation of both LSTM and GRU models, focusing on their predictive accuracy and the quality of the final visualizations.

## Proposed Solution

This project aims to develop an integrated pipeline for predicting and simulating the movement of marine debris around Malta's coastal waters. The process begins with the preprocessing of the sea surface currents datasets to be used as input for the subsequent modelling stages. A Lagrangian model will be developed using the OceanParcels toolkit, will be developed to visualise the debris movement. This approach is designed to clarify both the expected input from the AI models and the expected nature of the ensuing visualizations. The core of the solution involves developing and fine-tuning two types of machine learning models: LSTM and GRU. These models will undergo extensive testing to determine the optimal architecture and hyperparameters, aiming to accurately predict sea surface currents for a future 24-hour period.

Upon establishing the predictive models, the pipeline integrates these predictions into the Lagrangian model, transforming the predicted data into dynamic visualisations of future debris movement. The project culminates in a comparative analysis of the LSTM and GRU models, evaluating their effectiveness through various metrics, including their predictive accuracy and the quality of the generated visualisations. By analysing the results and visualisations, this project aims to provide actionable insights for effective cleanup operations and strategies for long-term marine conservation around the coastal waters of Malta.

## Automatically updating of Cross-Referencing

Although cross-referencing might feel like a cumbersome procedure, it will save you headaches and problems as you start editing your dissertation and moving things around or inserting new items. With cross-referencing, items will automatically be renumbered, and corresponding cross-references updated without any intervention from your end.

To force *Word* to automatically update the cross-referencing, select the entire document by pressing CTRL-A on your keyboard, followed by F9. Note that following this procedure, you may be asked to update the various tables of contents as well. It is always a good idea to force updating of cross-referencing using the above procedure, before printing the document.

### Using Styles Correctly (Style: Heading 3)

Using styles correctly will ensure consistent formatting of your dissertation and will also ensure adherence to the Faculty’s requirements. It also gives a professional look to your write-up.

It is also important to use consistent capitalisation in the section titles. It is recommended to capitalise each word in the title, except when using articles (a, an, the), coordinating conjunctions (and, but, for) and prepositions (at, by, to, etc.) unless these are the first word in the title.

#### Sub-Titles (Style: Heading 4)

Although a fourth level of sub-heading is available, you should be careful when to use it. Do not put text in sub-headings unnecessarily.

When using the Numbered List style, numbering will continue from a previous list (if any). To change this, simply right click on the first number in the list and select *Restart at 1*.

1. First item.
2. Second Item.
3. Third item.

## Some Hints on the Dissertation Writing Style

Here are some do’s and do not’s when writing the dissertation.

* Do not use contractions. For example, write “do not” not “don’t.” Write “would not” not “won’t” etc.
* Avoid using the first person. For example, do not write, “I performed the following experiments.” Instead write “The following experiments were performed.”
* Always follow a full-stop at the end of a sentence by two (not one) spaces.
* Always perform a spelling check before submitting your dissertation. Typos give the impression that you were careless in your write-up, which will not score well with the examiners.
* Always proofread your dissertation. You can either do this yourself or get a friend or a family member to do this for you. Never submit a dissertation after a typing round without this check. Missing words, misplaced words and other similar errors (which will not be picked up by a spell checker) will again give an impression of carelessness.
* Use British English throughout your dissertation, e.g., do not use “color” but rather “colour.”
* Do not write small numbers or round values (e.g., a thousand) using numeric literals within the text, instead write these using words. So do not write “2 examples”, instead write “two examples.”
* When using abbreviations and acronyms, always make sure that you first define these before first use. You do this by defining the term in full followed by the abbreviation or acronym in brackets. The full term should only be capitalised if it is a proper noun (e.g., the name of an organisation). For example, the headquarters of the International Olympic Committee (IOC) is based in Lausanne, Switzerland. Otherwise, do not capitalise the words in the term, e.g., the global positioning system (GPS) is very useful when travelling. Abbreviations and acronyms used should be listed in the List of Abbreviations. Only introduce an acronym if you are going to use the term more than three times in your dissertation, otherwise use the term in full.
* Be consistent in the use of variable names, i.e., always use the same variable name for the same quantity. Do not use the same variable name for different quantities. You have to be particularly careful when quoting equations from literature. In this case you need to change variable names, if required, to make equations consistent with your notation (and not the notation used in the cited paper).
* It is important that any figures used in the dissertation should be referred to and explained within the body of the text. Never put a figure without referring to it (such as Figure 1.1). Also make sure that captions for figures and tables clearly explain, in a succinct manner, what the item is showing.

Figure 1.1 Figure example, a rectangle and a triangle.

## Some Hints on using *Word*

The following are some hints on how to optimise your use of *Word*.

* If you wish two words to remain on the same line next to each other use a hard space instead of a normal space. In *Word* you insert a hard space by pressing CTRL-SHIFT-Space Bar.
* If you wish to keep two paragraphs on the same page, select the first paragraph and in the *Home* ribbon, expand the *Paragraph* section. In the resultant dialog box, select the *Line and Page Breaks* tab, as shown in Figure 1.2. Then tick the checkbox next to *Keep with next* and click *OK*. You can also tick the check-box next to *Keep lines together*, if instead you need to keep the selected lines together on the same page.
* Use keyboard shortcuts to access frequently used styles and other *Word* functions. Some keyboard shortcuts are already pre-defined in *Word*. You can modify these and define others yourself. For more information refer to the webpage on how to “Customize keyboard shortcuts” at: <https://support.microsoft.com/en-us/office/customize-keyboard-shortcuts-9a92343e-a781-4d5a-92f1-0f32e3ba5b4d#:~:text=Use%20a%20mouse%20to%20assign,the%20keyboard%20shortcut%20changes%20in>.
* You can automate repetitive tasks by recording a macro. Further information how this is achieved can be found by referring to the webpage “Create or run a macro” at <https://support.microsoft.com/en-us/office/create-or-run-a-macro-c6b99036-905c-49a6-818a-dfb98b7c3c9c>.
* It is recommended to save your document often. Ideally you should enable the autosave feature in *Word*.
* If you save your dissertation on *OneDrive*, previous versions of the document are automatically saved for you whenever you save your document. This will enable to revert back to a previous version should you wish to do so.
* If you click on the *Page* information on the status bar at the bottom of the screen you will enable the navigation pane on the left of the window. This way you can navigate your document in an easier manner.

Graphical user interface, text, application

Description automatically generated

Figure 1.2 Keeping paragraphs or lines on the same page.

## Avoiding Plagiarism

The dissertation is most probable the most significant piece of writing that you will undertake in your degree programme. It is therefore especially important to pay particular attention as to how avoid plagiarism. Always refer to the University’s guidelines on plagiarism. The background and literature review chapter is particularly prone for plagiarised sections. Always paraphrase in your own words when you are referring to other work and make sure that you properly cite the work (see Section **Error! Reference source not found.**). If you need to quote a particular text segment, make sure that you put this between quotation marks, again clearly citing the source of the quotation. If the quoted text is short (only a few words), then you can include this in-line with your text. However, if this is longer, a sentence or more, then put the quotation in a separate paragraph, using the *Quotation* style, as shown in the following example. Cockrum et al. assert that:

“Most engineering students learn by seeing examples of solved problems. This style is generally known as visual learning techniques.”

Other guidelines as to how to use this template may be found in Chapters 2 and 3.

## Appendices

Always specify what material is included in the appendices, if any, within the body of the dissertation. You can cross-reference the individual appendices using the reference type *Numbered Items* instead of the usual type *Heading*. For example, Appendix A gives more details regarding the use of appendices.

## How to Make a bulleted list

* Introduce the area and the final year project (FYP) without assuming that the reader has any special knowledge in the area.
* The aims and goals of the project.
* The approach used.
* Any assumptions.
* A high-level description of the project.
* An overview of the contents of the report.

When using a bulleted list, use the *Bulleted List* style as shown above.

# 

# Background and Literature Review

### Formatting the Reference Section

When the *Bibliography* setting is set to *On* in the *RefWorks Citation Manager*, the reference list is inserted at the end of the dissertation. However, this will not be in the correct format, nor in the correct position. To correctly format the Reference section, you need to first find this (in general this is placed at the end of the document). Then perform the following steps:

1. Click anywhere in the reference list. This should make the *Content Control* box containing the references visible, as shown in **Error! Reference source not found.**. On the top left-hand corner you should see three dots. Click on these dots. This selects the entire reference list.
2. Format the entire selection using the *References* style.
3. If you are using the IEEE reference style, with the reference list still selected, go to the *Home* ribbon, and click on *Replace* in the *Editing* section. In the resultant dialog box, type in “] ” next to *Find what* (note the space after the square bracket) and “]^t” next to *Replace with*, as shown in Figure 2.1. Then hit *Replace All*. Do not continue the replace operation beyond the selected text.
4. Make sure that you have the complete reference list selected as indicated in step 1. Move the selected reference list to the correct position within the dissertation (if it is not already in that position). The easiest way to do this is to *cut* the selection and *paste* this in the correct position.
5. Select the *References* title and apply the *Heading* style.

Graphical user interface, text, application

Description automatically generated

Figure 2.1 Correctly formatting the Reference section.

You need to perform the above steps every time that you switch on the *Bibliograph* switch in the *RefWorks Citation Manager*. It is therefore suggested that you either perform the above steps once you are done editing your dissertation, or else try to keep the *Bibliography* switch to *On*.

If you wish to automate the above process, you can include the macro given in Listing 2.1 and run this every time that you need to reformat the references section:

Listing 2.1 Macro to format references (Style: Code Listing).

Sub FormatReferences()

'

' FormatReferences Macro

'

'

ActiveDocument.SelectContentControlsByTag("rw.biblio").Item(1).Range.Select

Selection.Find.ClearFormatting

Selection.Find.Replacement.ClearFormatting

With Selection.Find

.Text = "] "

.Replacement.Text = "]^t"

.Forward = True

.Wrap = wdFindStop

.Format = False

.MatchCase = False

.MatchWholeWord = False

.MatchWildcards = False

.MatchSoundsLike = False

.MatchAllWordForms = False

End With

Selection.Find.Execute Replace:=wdReplaceAll

Selection.Style = ActiveDocument.Styles("References")

'The Harvard style does not have the References title included, so check for this

Selection.MoveUp Unit:=wdLine, Count:=1

Selection.MoveDown Unit:=wdLine, Count:=1

Selection.EndKey Unit:=wdLine, Extend:=wdExtend

If Left(Selection.Text, 10) <> "References" Then

' Check also one line up in case we've run this already

Selection.MoveUp Unit:=wdLine, Count:=1

Selection.EndKey Unit:=wdLine, Extend:=wdExtend

If Left(Selection.Text, 10) <> "References" Then

Selection.MoveDown Unit:=wdLine, Count:=1

Selection.HomeKey Unit:=wdLine

Selection.TypeParagraph

Selection.MoveUp Unit:=wdLine, Count:=1

Selection.TypeText Text:="References"

Else

Exit Sub

End If

End If

Selection.HomeKey Unit:=wdLine

Selection.Style = ActiveDocument.Styles("Headings")

End Sub

Note that the *Code Listing*  style is applied to the above code segment.

If you are not familiar with *Word* macros, you can read how to install this by referring to <https://support.microsoft.com/en-us/office/create-or-run-a-macro-c6b99036-905c-49a6-818a-dfb98b7c3c9c>. In particular, refer to the section “Write a macro from scratch in Visual Basic.”

## Writing the Background and Literature Review Chapter

The purpose of the background section is to provide the reader with information that they cannot be expected to know but which they will need in order to fully understand and appreciate the rest of the project.

This section may describe such things as:

* the wider context of the project;
* the anticipated benefits of the system;
* the likely users of the system;
* any theory associated with the project;
* the software/hardware development method(s) used;
* any special diagramming conventions used;
* existing software (or hardware) that is relevant to the system;
* etc.

Since projects will likely include different kinds of theory, programming language choices, compilers, software/hardware components, APIs, development boards, IC technologies, one cannot always assume that the reader will be familiar with the details of all of them. The student should therefore explain concepts and use references to guide the reader.

The literature review component of the report should include:

* A study in the area of interested, highlighting the strengths and weaknesses of existing methods.
* A review of the state-of-the-art published material in the area.
* A critical analysis of exiting material and methods.
* An explanation showing why the literature chosen to review is relevant to the FYP.

# Specification and Design

## Further use of Captions

We have already seen the use of captions for figures and equations. Recall that this will allow automatic cross-referencing within *Word*. In addition to figures, you can also use captions to number and cross-reference other items in your dissertation.

### Tables

Tables 3.1 and 3.2 show two example tables. Notice that in the case of tables, the table caption needs to be placed above the table and assigned the *Caption Table* style. Also note that *Word* does not allow inserting a cross-reference without using the caption label. This creates a problem when referencing more than one item (in this case, tables) at the same time, like we do at the start of this paragraph. In order to solve this problem, we need to manually edit the inserted cross-reference field as follows. Insert the cross-reference as normal (select *References* ribbon; click on *Cross-reference*; select *Table* under *Reference type*; select *Only label and number*  under *Insert reference to*; select the table that you wish to refer to and then click *Insert*). This will create a cross-reference like Table 3.1. To remove the label and retain only the table number, click anywhere on this cross-reference and press SHIFT-F9 on your keyboard. This should reveal the field code used by *Word* to keep track of the cross-reference and should look something like { REF \_Ref119834227 \h } (the label will be different in your case). To display just the cross-reference number, insert the text \# "0.0" after \h in the field code to make it look like { REF \_Ref119834227 \h \# "0.0" }. With the cursor still somewhere in the field code press F9 on your keyboard. This should now display just the cross-reference number.

Table 3.1 Simple table example.

| Header 1 | Header 2 | Header 3 |
| --- | --- | --- |
| 1 | 2.3 | Orange |
| 2 | 100.5 | Blue |
| 3 | 35.0 | Black |

Notice that the table header is applied the style *Table Col Head*, whereas the body of the table is applied the *Table Body* style. Sometimes you may need to modify these styles to adapt to the data being displayed. For example, in Table 3.1 the data in the second column contains numbers accurate to the first decimal point. To centre these properly in the column with the numbers aligned based on the position of the decimal point, you need to insert a decimal tab at the centre of the column and align the column to be left justified.

Table 3.2 shows a more complicated table example. Notice that the column sub-headers are assigned the style *Table Col Subhead*. Also note that even though the numbers under the third subheading are without a decimal point, they are still aligned on their virtual decimal point position as explained in the previous paragraph.

Table 3.2 A more complicated table example.

| Table Head | Table Column Head | | |
| --- | --- | --- | --- |
| Table column subhead 1 | Table column subhead 2 | Table column subhead 3 |
| Item 1 | Item 2 | Item 3 | 100 |
| Item 4 | Item 5 | Item 6 | 2 |
| Item 7 | Item 8 | Item 9 | 10000 |

The paragraph immediately following a table should be assigned the *Dissertation Body after Table* style so as to maintain the correct spacing from the table.

### Lemmas, Theorems, Corollaries etc.

You can also use captions to number lemmas, theorems, corollaries and other items. To define a new numbering sequence, you need to define a new caption label in *Word*. Unfortunately, these new caption labels are not stored with the document itself, so you would need to define these yourself, on a need to basis.

For example, to define a new caption for lemmas, select the *References* ribbon and then click on *Insert Caption*. This will open a similar dialog as the one shown on the left of **Error! Reference source not found.** on page **Error! Bookmark not defined.**[[1]](#footnote-1). In the *Insert Caption* dialog box, create a new label by clicking the *New label …* button. Enter the label *Lemma* for this example (or any other item type, such as *Theorem* etc.) and press *OK*. Then click on the *Numbering …* button and in the resultant dialog box (similar to the one on the right-hand side of **Error! Reference source not found.**) tick the *Include chapter number* checkbox and select the period for the number separator. Once you define the new caption label, you can start using it in the same way as for inserting captions for figures.

The inserted caption will be applied automatically the *Caption* style. Instead, manually apply the *Labels* style to the newly inserted caption as shown in the example below for Lemma 3.1. To put the label (Lemma in this case) and the number in bold, select these manually and apply the style *Labels Bold*. When inserting a cross-reference in this case, the cross-reference will also be shown in bold within the text and you have to manually remove this character formatting.

Lemma 3.1 The Earth is a sphere. (Style: Labels)

Note that Lemmas 3.1 and 3.2 will be used to prove Theorem 3.1.

Lemma 3.2 The Earth rotates around the sun.

If a cross-reference becomes bold again on updating, then edit the corresponding field code to include the switches “\\* MERGEFORMAT” at the end of the field code.

Theorem 3.1 The Earth is one planet in the Solar System. (Style: Labels)

Proof: Using Lemmas 3.1 and 3.2 and observational data … (Style: Proof)

Note that the style for the Proof section is *Proof*, but you need to set the word *Proof* in italic by applying the style *Proof Italic* to it.

Captions for code listings may also be defined, as for Listing 3.1shown below.

Listing 3.1 Example code (Style: Labels)

# include <stdio.h> //(Style: Code Listing)

int main()

{

return 0;

}

Captions for algorithms may also be defined, as shown for Algorithm 3.1below. In the case of an algorithm, you need to convert the text to a table manually as sown in Algorithm 3.1. Note that the paragraph before an algorithm should have its *After spacing* set to 12 pt, as in this case. The Algorithm style used to write the algorithm proper automatically creates the line numbering.

|  |
| --- |
| Algorithm 3.1 Title of Algorithm (Style: Labels) |
| 1. inputs and outputs (Style: Algorithm) 2. **for** i: 1 … k **do** 4. … |

## Chapter Headers

In this template, automatic chapter headers appear on the top right-hand corner of each page. This enables easier navigation within the dissertation when reading it. In general, you do not need to change anything to make these work. However, if you insert new chapters, you must adhere to a couple of points not to break this feature.

When inserting a new *Heading 1* style, the style is automatically setup to start on a new page. However, this is not enough to make the chapter headings work correctly. You also need to insert a *Continuous Section Break* before the new chapter title. You can do this by moving the cursor at the start of the new chapter title. Then from the *Layout* ribbon click on *Breaks* and then click *Continuous* under the *Section Breaks*. The headers are set to be different in the first section page compared to the rest of the section so that the chapter header does not appear on the first page of the chapter. The headers are also linked to previous headers, so that you will not need to insert any field codes in the headers yourself. Notice that section breaks are in general hidden. To view these and other control characters in *Word* you need to toggle these by pressing CTRL-SHIFT-8 on the keyboard. You can also access this option from the *Home* ribbon by clicking the pilcrow button in the *Paragraph* section.

## Printing the Dissertation on Both Sides

This template is intended to create a dissertation that is printed only on one side of the paper (the left margin is wider than the right to allow for binding on the left). If you intend to print this dissertation on both sides of the paper, then you need to make some adjustments to facilitate this. It is highly recommended that you make a copy of the original document, just in case you may need to revert to the original single-sided version.

From the *Layout* ribbon, click on the corner arrow in the *Page Setup* section to open up the full range of page setup options and then select the *Layout* tab as shown in Figure 3.1. In the *Section start* drop-down box, select *Continuous*. In the *Headers and footers* section, tick the checkbox *Different odd and even*. In the *Apply to* drop-down box, select *Whole document*. Then click on the *OK* button. This correctly sets the gutter to be always on the inside of the page to enable correct binding.

You also need to correct the document’s headers and footers which are now different for odd and even numbered pages. Go to the *Abstract* page (page 2). You will notice that this now does not have page numbers. Double click in the footer area of this page, and you should enter the editor for the *Header and Footer* of the page. Over the footer area, you should see the label *Even Page Footer – Section 1*. From the *Header & Footer* ribbon, click on *Next* in the *Navigation* section. This should place you in the footer of the page labelled as *Odd Page Footer – Section 1*. Select the page number and copy and paste it in the previous *Even Page Footer – Section 1* by clicking on the *Previous* button to navigate back to the previous section.

Now navigate to the header area labelled *Even Page Header – Section 2*. If you retained the original document layout, this should land you on the second page of the Introduction chapter. In the *Header & Footer* ribbon, make sure that the *Link to Previous* selection is unselected.Then, from the *Insert* ribbon, click on the *Quick Parts* button in the *Text* section and then click on *Field*. In the dialog box that opens, select *StyleRef* under *Field names*. Under *Style names* select *Heading 1* and tick the check box next to *Insert paragraph number*. These selections are shown in Figure 3.2. Then press *OK*.

The above steps should insert the number 1 in the header (corresponding to chapter 1). Now, we need to insert the chapter title itself. Enter a space after the chapter number and then repeat the steps in the previous paragraph, but this time leave the *Insert paragraph number* checkbox unticked. This should insert the chapter title. The last step is to left-justify this header so that it always appears on the outside of the page.

Graphical user interface, application

Description automatically generated

Figure 3.1 Converting document to printing on both sides.

You should also check the headers on other pages to make sure that everything appears correctly and to edit the headers as necessary.

Graphical user interface, application, Word

Description automatically generated

Figure 3.2 Inserting chapter headers.

## Writing the Specification and Design Chapter

The purpose of this section is to give the reader a clear picture of the system/artifact/project/work that has been created in the FYP and why it has been created in the way chosen.

Details:

* Any design choices have to be justified (e.g., by discussing the implications of different design choices and then giving reasons for making the choices made).
* Fine details, specifically details of the system (software or hardware) should be left out. Also, any complete rigorous specification is better relegated to an appendix.
* Using diagrams (including but not limited to flowcharts and system level block diagrams) is strongly recommended.
* The design of the project will almost certainly have evolved during development. Focus should be made on the project as it is in its final state but often there are good reasons for describing intermediate states too (e.g., to discuss details of the design method used).

# Implementation

## Writing the Implementation Chapter

The Implementation section is similar to the Specification and Design section in that it describes the system but it does so at a finer level of detail, generally down to the code/theorem/algorithm/circuit/hardware… level. It can also describe any problems that may have arisen during implementation.

* In case of a software development describing of all the code in the system should be avoided as well as large “pieces” of code. Complete source code listings should be put on the accompanying digital media. In case of hardware the system should be divided into sub-systems or circuits that may be easily described and analysed.
* One must be especially critical to the operation of the system.
* Mentioning unforeseen problems encountered during implementation and how these are solved.

# Testing and/or Evaluation

## Writing the Evaluation and/or Evaluation Chapter

The testing and/or evaluation component of an FYP is critical.

* One has to make sure and explain why all tests used to evaluate the system are relevant, using evidence from the literature about similar systems, and justifying any deviations from standard approaches.
* Demonstration that system works as intended (or not, as the case may be).
* Include comprehensible summaries of the results of all critical tests that have been made.
* The student must also critically evaluate the system in the light of these tests results, describing its strengths and weaknesses.
* Ideas for improving it can be carried over into the Future Work section.
* Comparison of practical with theoretical results and their interpretation.
* Comparison with published work when available.

# Future Work

## Writing the Future Work Chapter

Whether by the end of the project all the original aims and objectives have been completed or not, there is always scope for future work. Also, the ideas will have evolved during the course of the project beyond the original target. The Future Work section is for expressing these ideas.

# Conclusions

## Writing the Conclusions Chapter

The Conclusions section should be a summary of the project and a restatement of its main results, i.e. what has been learnt and what it has achieved. An effective set of conclusions should not introduce new material. Instead, it should draw out, summarise, combine and reiterate the main points that have been made in the body of the report and present opinions based on them.

The Conclusions section marks the end of the report proper.

References

stylefix

Bibliography

List here work that you have referred to during your work, but which you did not cite in the body of the dissertation. Same style and formatting rules as for references apply here (see Section 2.1.1). However, in the case of the IEEE style, there will be no citation numbers.

1. When to Use Appendices (Style: Appendix Heading 1)

When inserting a new appendix use the Appendix Heading 1 style. The appendix numbering and the word “Appendix” are inserted automatically.

* 1. Appendices Headings (Style: Appendix Heading 2)

When inserting appendix headings, use the corresponding Appendix Heading style according to the required level.

* + 1. Appendix Sub-Headings (Style: Appendix Heading 3)

Only three levels are defined for appendices.

* 1. What to put in Appendices

Appendices are repositories for material which the student wishes to include in the report but which would seriously obstruct the flow of ideas put anywhere in the main body. Copies of the final version of any code should be avoided – the code must be available digitally on accompanying media.

Examples of items that could go in appendices are:

* A glossary of terms.
* Fundamental and basic theory.
* Schematic Diagrams and PCB/IC layout snap shots.
* Detailed notes on the programming language chosen or hardware platform used or technology used in an IC environment.
* A user’s guide.

1. Version Information

|  |  |
| --- | --- |
| Version Number: | 1.1 |
| Date: | 30 November 2022 |
| Version Information: | * Changed fonts to Lato. * Given instructions how to install Lato font. * Clarified location of IEEE – Faculty of ICT style. |
| Author: | Prof Inġ Victor Buttigieg |
|  |  |
| Version Number: | 1.0 |
| Date: | 19 November 2022 |
| Version Information: | First version of the FYP dissertation template. |
| Author: | Prof Inġ Victor Buttigieg |

* 1. Copyright Information

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References

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1. When you are referencing a figure (or some other item) which is far away from the current position in the document, it is a good idea to include the page number where the item is located. You can do this using cross-referencing as well, by selecting *Page Number* under *Insert reference to* in the cross-reference dialog box. [↑](#footnote-ref-1)