# Gait sequence modelling and estimation

## using Hidden Markov Models


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# Declaration

1. I know that plagiarism is wrong. Plagiarism is to use another's work and pretend that it is one's own.
2. I have used the IEEE convention for citation and referencing. Each contribution to, and quotation in, this report from the work(s) of other people has been attributed, and has been cited and referenced.
3. This report is my own work.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as their own work or part thereof.

Signature:.....
Kouame H. Kouassi

Date:.....

# Acknowledgments

# Abstract


- Open the **Project Report Template.tex** file and carefully follow the comments (starting with %).
- Process the file with **pdflatex**, using other processors may need you to change some features such as graphics types.
- Note the files included in the **Project Report Template.tex** (with the .tex extension excluded). You can open these files separately and modify their contents or create new ones.
- Contact the latex namual for more features in your document such as equations, subfigures, footnotes, subscripts & superscripts, special characters etc.
- I recommend using the **kile** latex IDE, as it is simple to use.

# Contents

# Chapter 1

# Introduction

## 1.1 Background to the study

A very brief background to your area of research. Start off with a general introduction to the area and then narrow it down to your focus area. Used to set the scene [1].

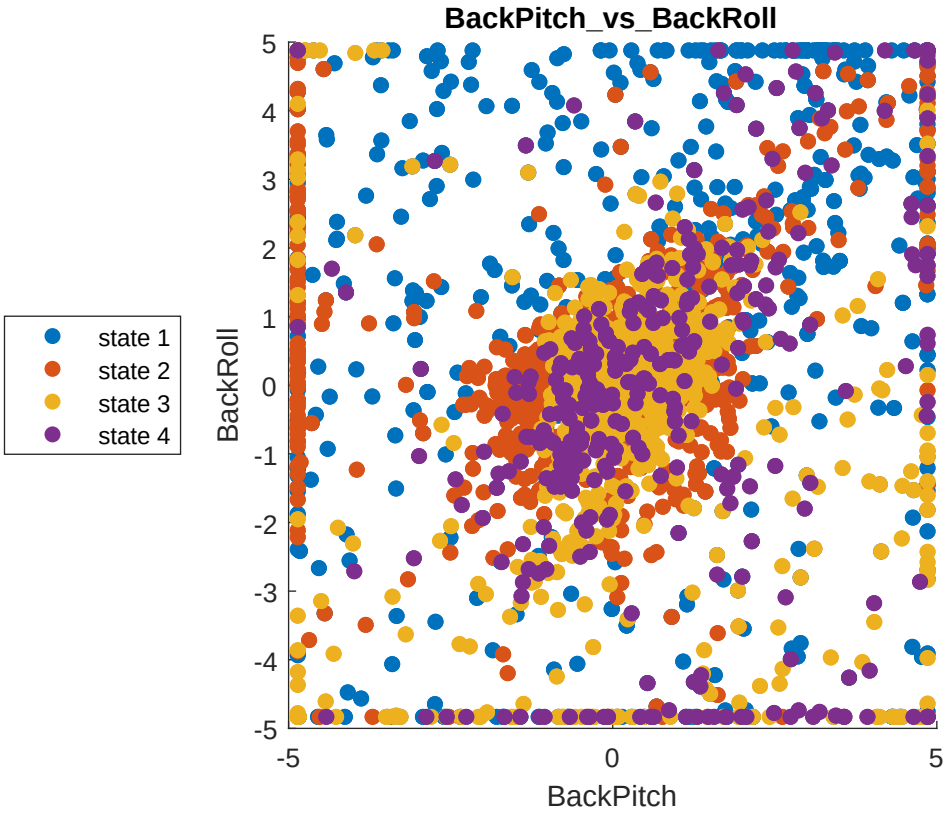
## 1.2 Objectives of this study

### 1.2.1 Problems to be investigated

Description of the main questions to be investigated in this study.

### 1.2.2 Purpose of the study

Give the significance of investigating these problems. It must be obvious why you are doing this study and why it is relevant.




## 1.3 Scope and Limitations

Scope indicates to the reader what has and has not been included in the study. Limitations tell the reader what factors influenced the study such as sample size, time etc. It is not a section for excuses as to why your project may or may not have worked.

## 1.4 Plan of development

Here you tell the reader how your report has been organised and what is included in each chapter.

**I recommend that you write this section last. You can then tailor it to your report.**

# Chapter 2

# Literature Review

Once upon a time engineers and researchers believed... In this area of research, they used the following methods... [2]

Write this section first as it will take you the longest. I suggest you start writing this as soon as you have done your initial research at the beginning of your project. You can then return to it once you have completed your work to edit and adjust it.

A literature review forms the theoretical basis of your project. You need to read a large number of journal papers, sections in books, technical reports etc. relevant to your work at the start of project. This will give you a good idea of the field of research.

When writing your review start of with the general concepts and move to the more specific aspects explaining the necessary theory as you go. This section is NOT a copy and paste from others work or a rewrite-but-change-one-word section. I suggest you read all your material, and then put it down and write this section, referring back to the work only when you need to check something.

See your PCS textbook for more details on how to write a literature review.

If you include a figure or a table in your text please see the example in Fig. 2.1 as to how to caption it. Please make sure that all text in your figures is readable and that you reference your figures if they are from another source.

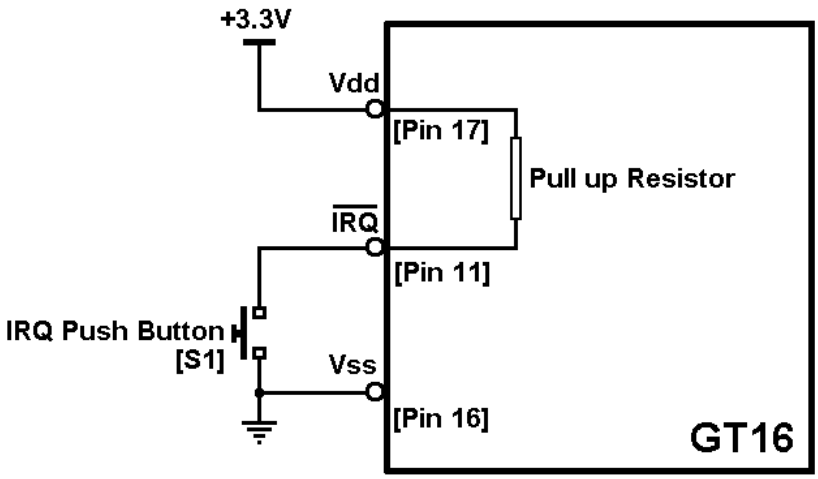



Figure 2.1: A block diagram illustrating the connections to the IRQ pin on the MCS08GT16A microcontroller (Please note that your headings should be short descriptions of what is in the diagram not simply the figure title)

## 2.1 Gait sequence modelling and estimation

### 2.1.1 Quadrupede gait modelling

#### Periodicity

### 2.1.2 Quadrupede gait estimation

## 2.2 Case study: Inertia Measurement Unit

## 2.3 Hidden Markov Models

Assumption of statistical model: Signal can be parametrised as a parametric random process and that the parametrers of the stochastic process can be determined/estimated in a precise, well-defined manner.
Observation is a probabilitistic function of the state - doubly embedded stochastic process. Each state characterised by the probability distribution of observations, and transitions between states are characterised by a state transition matrix.

**First order Markov model - current and predecessor only considered**

### 2.3.1 Transition Probability Matrix

### 2.3.2 Emission Probability Matrix

### 2.3.3 Initial distribution

### 2.3.4 Elements of an HMM

1. Number of states, N
2. Number of distinct observation symbols per state, M
3. The initial state distribution, pi

### 2.3.5 Three fundamental problems for HMM design

1. Number of states, N
2. Number of distinct observation symbols per state, M

### 2.3.6 Types of HMM

**Ergodic model**

**Left-Right model or Bakis model**

**Evaluation of the probability of a sequence of observations**

**The determination of a best sequence states**

**The adjustment of model parameters to account for observed signal**

## 2.4 k-Nearest Neighbour

## 2.5 Dimension reduction

### 2.5.1 Feature selection

## 2.6 Sufficiency of Training Data

## 2.7 Techniques to increase Training Data

### 2.7.1 Mirroring

# Chapter 3

# Methodology

This is what I did to test and confirm my hypothesis.

You may want to split this chapter into sub chapters depending on your design. I suggest you change the title to something more specific to your project.

This is where you describe your design process in detail, from component/device selection to actual design implementation, to how you tested your system. Remember detail is important in technical writing. Do not just write I used a computer give the computer specifications or the oscilloscopes part number. Describe the system in enough detail so that someone else can replicate your design as well as your testing methodology.

If you use or design code for your system, represent it as flow diagrams in text.

## 3.1 Nature of the available data

### 3.1.1 Source: IMU for a moving dog

**stationary: statistical property do not vary over time or non-stationary: properties vary over time**

**pure or corrupted?**

### 3.1.2 Nature: continuous observations - Finite and discrete States

## 3.2 HMM Design

### 3.2.1 Nature and Number of states

### 3.2.2 Nature and Number of observations - IMU measurements

### 3.2.3 Dimension reduction

**From 18 to 4 features using classification with knn**

### 3.2.4 Continuous observations/features to Discrete observations/features

# Chapter 4

# Results

These are the results I found from my investigation.

Present your results in a suitable format using tables and graphs where necessary. Remember to refer to them in text and caption them properly.

## 4.1 Aim

The objetive of this project is to design, implement and evaluate an algorithm, a model or a machine to predict the gait sequence of an animal (quadrupede or bipede) using Markov models. Thus, for a given state S, the model should be able to predict the next state S + 1, with a certain degree of confidence.

## 4.2 Apparatus

## 4.3 Methods

## 4.4 Results

## 4.5 Analysis

### 4.5.1 Discrete Probability density function duration d in state i

### 4.5.2 Expected number of observations (duration) in a state

## 4.6 Experimental Results

# Chapter 5

# Discussion

Here is what the results mean and how they tie to existing literature...

Discuss the relevance of your results and how they fit into the theoretical work you described in your literature review.

# Chapter 6

# Conclusions

These are the conclusions from the investivation and how the investigation changes things in this field or contributes to current knowledge...

Draw suitable and intelligent conclusions from your results and subsequent discussion.

# Chapter 7

# Recommendations

Make sensible recommendations for further work.

Use the IEEE numbered reference style for referencing your work as shown in your thesis guidelines. Please remember that the majority of your referenced work should be from journal articles, technical reports and books not online sources such as Wikipedia.

# Bibliography

[1] M. S. Tsoeu and M. Braae, "Control Systems," *IEEE*, **vol. 34(3)**, pp. 123-129, 2011.

[2] J. C. Tapson, *Instrumentation*, UCT Press, Cape Town, 2010.

# Appendix A

# Additional Files and Schematics

Add any information here that you would like to have in your project but is not necessary in the main text. Remember to refer to it in the main text. Separate your appendices based on what they are for example. Equation derivations in Appendix A and code in Appendix B etc.

# Appendix B

# Addenda

## B.1 Ethics Forms