Research Methodology Part III: Thesis Proposal

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Outline

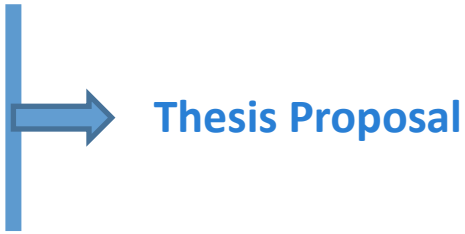
- Thesis Phases
- Thesis Proposal Sections
- Thesis Flow Chart

Thesis Phases

1. **Choose the research title**
2. **Plan the research**
3. **Execute the research**
4. **Write the research / thesis**

Thesis Phases

1. **Choose the research title**
2. **Plan the research**



3. **Execute the research**
4. **Write the research / thesis**

Thesis Phases

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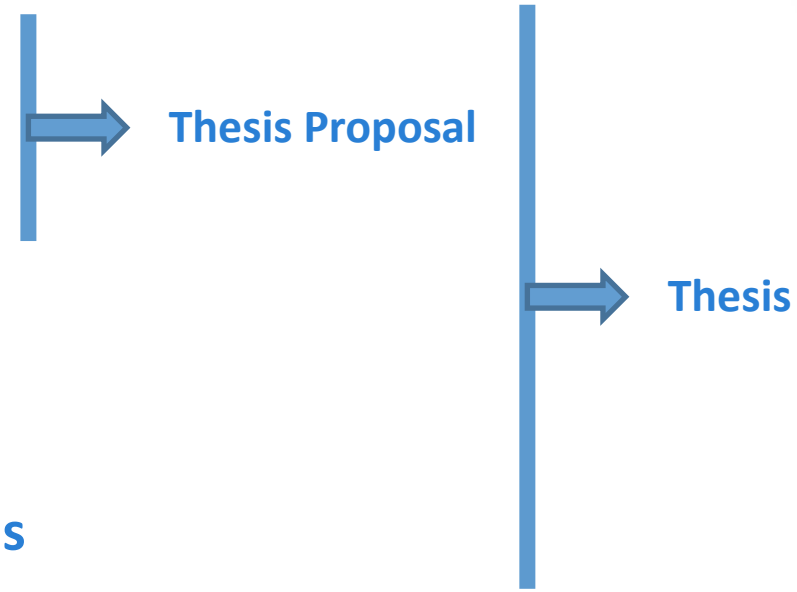


Thesis Phases

1. **Choose the Research Title**
   - Choose an advisor *for your thesis work*
   - Initiate research problem
   - Do initial literature review
   - Define research problem
   - Propose title
   - Submit the ***Thesis Title*** document

Thesis Phases

2. Plan the Research

- Do comprehensive literature review
- Focus the research problem
- Propose research methodology
  - Specify models and/or algorithms to use
  - Specify equipment to use
  - Specify data-gathering technique
  - Specify evaluation technique
- Identify originality and significance of your work
- Identify the objectives and expected outcomes
- Show the research-work time-line
- Submit the ***Thesis Proposal*** document

Thesis Phases

3. **Execute the Research**
   - Develop / derive any needed theoretical work such as:
     - Models
     - Methods
     - Algorithms
   - Apply the developed models and methods using simulation and/or experiments
   - Collect data
   - Analyze results
   - Validate your work

Thesis Phases

4. **Write the Research / Thesis**
   - Extend the research proposal
     - Write an abstract
     - Add to the literature review
   - Modify existing sections
   - Document any theoretical work
   - Present the research results, such as data
   - Analyze and validate results
   - Write the conclusion
   - Write and revise the thesis
   - Submit your ***Thesis***

Thesis Proposal Sections

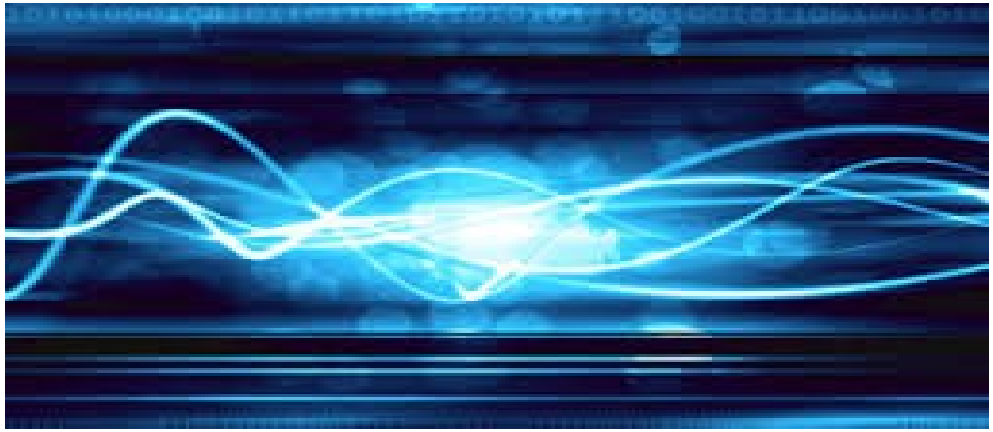
1. Introduction
2. Literature Review
3. Theoretical background
4. Research Plan
5. Conclusion and Future Work

References

Abstract

- Abstract is a concise and direct one-paragraph that describes the contents of the article. It should be an overview of the most important elements of the article:
  - Objective
  - Methodology
  - Results
  - Conclusion

- **Note**: Abstract is part of the Thesis (not the Thesis proposal)



Abstract Example

- **Objective**
- **Methodology**
- **Results / Conclusions**

This paper presents a method to identify and control electro-pneumatic servo drives in a real-time environment. Acquiring the system's transfer function accurately can be difficult for nonlinear systems. Therefore, a Mixed-Reality Environment (MRE) is employed to identify the transfer function of the system using a Recursive Least Squares (RLS) algorithm based on the Auto-Regressive Moving-Average (ARMA) model. On-line system identification can be conducted effectively and efficiently using the proposed method. The advantages of the proposed method include high accuracy in the identified system, low cost, and time reduction in tuning the controller parameters. Furthermore, the proposed method allows for on-line system control using different control schemes. The results, obtained from the on-line experimental measured data, are compared to the identified transfer function and show that the proposed methodology is able to estimate and control system behavior.

Saleem, Abd Rabbo, and Tutunji, "On-line identification and control of pneumatic servo drives via a mixed-reality environment", *International Journal of Adv. Manufacturing Technology*, 2008

Introduction

1. **Introduction**
   - Summary of the research question
   - Motivations why it is important
   - Problem in general
   - Focus to your research statement
   - Write your hypothesis
     - State your thesis statement
   - Identify objectives
   - Identify originality
   - Identify significance
   - List expected outcomes

Introduction Example

Unmanned Aerial Vehicles (UAV) are becoming very attractive for the civil applications such as forest fire detection, traffic surveillance, rescue missions, environment monitoring, and agricultural spraying.

Interest for research in the UAV has been increased by the recent achievement in Micro Electromechanical Systems (MEMS), power storage, microcontrollers, communications, electronics miniaturization, automation and control.

The UAV can be grouped in two main categories: Fixed wings and rotary wing. One of the most used rotary wings vehicle is the quad-rotor. Compared with fixed wings aerial vehicle, the quad-rotor has several advantages such as: Vertical take-off and landing, hovering capabilities, flying at a lower speed, and high maneuverability in restricted area.

Stanculeanu and Borangiu Quadrotor. "Black-Box System Identification", *World of Science, Engineering, and Technology*, Vol 5, 2011

Introduction Example

However, quad-rotors are difficult to control because of their unstable and high coupled dynamic system and unstability. Therefore, there is an interest in developing mathematical models using system identification.

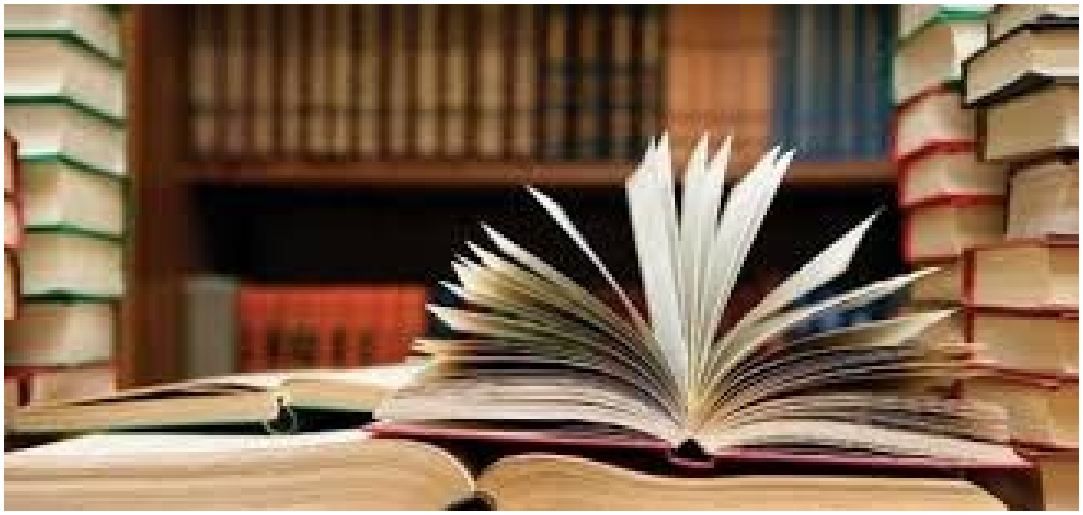
The most commonly-used methods for modeling quad-rotors are based on Newton-Euler and Euler-Lagrange models. However, these dynamic models use the forces and moments as inputs.

The work in this paper is focused on using Multi-Input Multi-Output (MIMO) identification for quad-rotors using motor commands as inputs.

Literature Review

2. Literature Review

- Survey of what others did
- Synthesis their work
- Identify gaps
- Position your research



Literature Review Example

Hardware-in-the-loop (HIL) simulation enables the operation and testing of actual components of a system along with virtual computer-based simulation models of the rest of the system in real time [1,2]. In a typical HIL test, the hardware component consists of a box of electronic components which can communicate with the software models via electrical signals exchanged using a data acquisition card [3]. Several studies have been reported for the use of HIL simulation approach for rapid prototyping of electronic control unit (ECU) of turbojet [4–6] and turbofan engines [7–9].

Recently, the use of HIL simulation to test the mechanical and other components has been attracted. Such simulations which have significant power flows between the real hardware and simulation make their design more challenging. This kind of HIL simulation is often called actuator-based HIL simulation or dynamic substructuring. Gawthrop et al. [3,10] presented an overview to the topic of real-time dynamic substructuring in variety of applications.

Montazeri-Gh et al, "Actuator-based hardware-in-the-loop testing of a jet engine fuel control unit in flight conditions". *SIMPAT* 2012

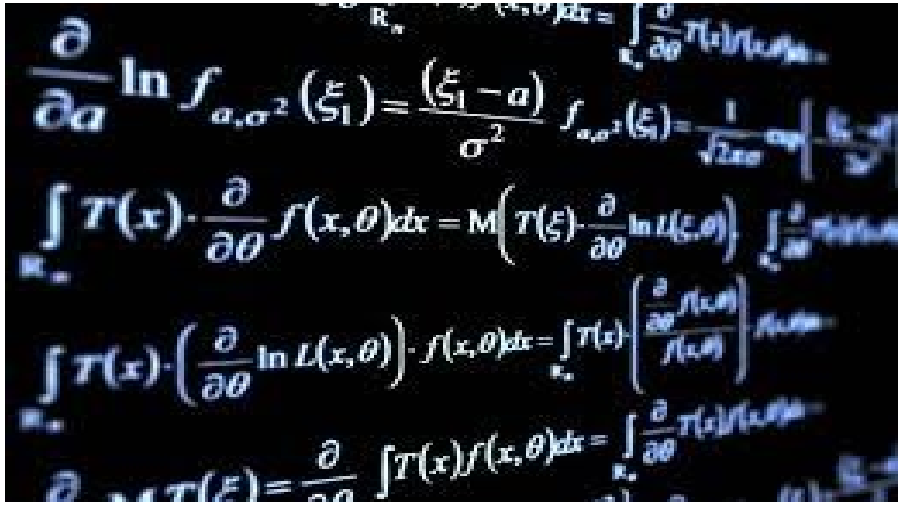
Literature Review Example

In the field of aerospace engineering, several researches have been undertaken to employ the concept of the HIL simulation to examine the performance of aircraft vehicle components within a closed loop virtual simulation of the remaining subsystems. For instance, the authors in [11] have presented the development of an HIL simulation for testing of vision based control systems for unmanned aircraft vehicles (UAVs). The authors have explained how to integrate a camera-in-the-loop simulation with the model aircraft in a wind tunnel. In addition, the study reported in [12] has addressed the testing of electro- hydraulic actuators and their interactions with the representative environment by emulating the aerodynamic loads caused by the aircraft control surfaces. In [13], a study of the performance of a fuel-cell-powered UAV using an HIL simulation of the aircraft in flight has been presented. The authors of [14,15] have presented an integrated flight control development to implement and test the flight controllers on small unmanned aircraft vehicle systems. However, the use of HIL simulation for testing of jet engine fuel control unit (FCU) in flight condition has not been studied.

Theoretical Background

2. Theoretical Background

- Explain mathematical backgrounds
- Explain related models
- Explain related methods



Theoretical Background Example

II. INDUCTION MOTORS MATHEMATICAL MODEL

The induction motor is modeled using the two –axis d-q theory in the rotating reference frame of the machine variables as follows:

A. Electrical description

As in Ertem and Baghzouz [10], the d-q flux linkage equations of the stator and rotor circuits are given by;

$$\dot{\psi}_{ds} = \nu_{ds} - \frac{R_s L_r}{\sigma}\Psi_{ds} + \frac{R_s L_m}{\sigma}\Psi_{dr} + \omega_o \Psi_{qs} \quad (1)$$

$$\dot{\Psi}_{qs} = \nu_{qs} - \frac{R_s L_r}{\sigma}\Psi_{qs} + \frac{R_s L_m}{\sigma}\Psi_{qr} - \omega_o \Psi_{ds} \quad (2)$$

$$\dot{\Psi}_{dr} = -\frac{R_r L_s}{\sigma}\Psi_{dr} + \frac{R_r L_m}{\sigma}\Psi_{ds} + (\omega_o - \omega)\Psi_{qr} \quad (3)$$

$$\dot{\Psi}_{qr} = -\frac{R_r L_s}{\sigma}\Psi_{qr} + \frac{R_r L_m}{\sigma}\Psi_{qs} - (\omega_o - \omega)\Psi_{dr} \quad (4)$$

Where

$L_s = L_{is} + L_m$

$L_r = L_{ir} + L_m$

$\sigma = L_S L_r - L_m^2$ ...

B. Electromechanical description

The developed electromagnetic torque of the induction motor is expressed in term of the machine variables as,

$$T_e = (m/2)(p/2)(L_m/\sigma)(\Psi_{qs}\Psi_{dr} - \Psi_{ds}\Psi_{qr}) \quad (9)$$

The flux linkage values are calculated from the electrical dynamic model, and substituted into equation (9) to give the transient electromagnetic torque. The flux linkage values are calculated from the static electrical model to give the steady state torque.

C. Mechanical description

Instantaneous rotor electrical speed derivative could be obtained from the torque balance equation as,

$$(J/p/2)\dot{\omega} = T_e - T_L \quad (10)$$

...

Saleem, Tutunji, and Issa, "On-Line Identification of Induction Motors: Experiments and Results", 5th International Symposium on Mechatronics and its Applications, Amman-Jordan May 27-29, 2008

Research Plan

3. Research Plan

- Describe **methodology** to use
  - Methods
  - Data collecting procedure
    - Includes variables to measure
    - Includes Instruments to use
  - Evaluation / validation technique

- Show your **research timeline**

Research Plan: Methods

- What mathematical models will be used?
- Examples
  - Differential equations based on Newton
  - Auto-Regressive Models
  - Dynamic Neural Network
- What algorithms will be used?
- Examples
  - Recursive Least Square
  - Proportional Derivative
- How will the different methods and algorithms be combined
- Example
  - ARMA model and RLS algorithm will be used estimate the transfer function
  - PID controller will be used with the estimated model

Research Plan: Data Collection

- Measured variables
  - What value(s) do you want to measure?
  - Force, voltage, position, pressure, …
- Size
  - How many data points do you want to collect?
  - What is the sampling size?
  - Justify your answer
- Techniques
  - How will the data be measured / collected?
    - Field data
    - Lab experiments. What lab equipment and setup is needed?
    - Simulation. What software and simulation parameters?
- Sensitivity and Reliability
  - How many runs? Will different runs give same results?
  - Are there any random signals involved?
  - Any disturbance or noise?

Research Plan: Validation

- Validation involves
  - Collecting evidence using proper methods
  - Organizing an argument
  - Convincing readers that your research statement is correct

- Validation can be done using
  - **Mathematical proof**
    - Show a mathematical proof that your method works
  - **Benchmarking**
    - Comparing your results (simulation and/or experiments) with well-known methods

Methodology Example

- The proposed work is to control induction motors at varying loads using fuzzy control. The plan is to collect real-time data from an induction motor and to use this data to identify the motor model. The change of loads will be accomplished by applying different load torques in the lab.

- Nonlinear models, neural networks, will be used to identify the induction motor model. The backpropagation algorithm will be used to converge the parameters of a 3-layer dynamic network. Then, fuzzy controller will be used to control the motor's response.

- A 5-volt step will be applied to the motor and the speed response will be measured and collected. A computer with Data Acquisition Card (DAQ) would be used to interface with the motor and a tachometer will be used to measure the motor's speed. Data will be collected for two minutes with sampling time of 10 Sample-per-second

Methodology Example

- The identified model will be used in a simulation environment for the purpose of designing the fuzzy controller. The designed controller will be tested and applied to induction motor through Hardware-In-the-Loop (HIL) environment.

- Simulated results (using MATLAB) and experimental results (collected from the lab setup) will be used to evaluate the proposed work. The designed controller will be compared to a cascade-PID controller. The response time and sum-square-error between the desired speed profile and controller correction will be the evaluation criteria.

Research Plan: Graphical Planning

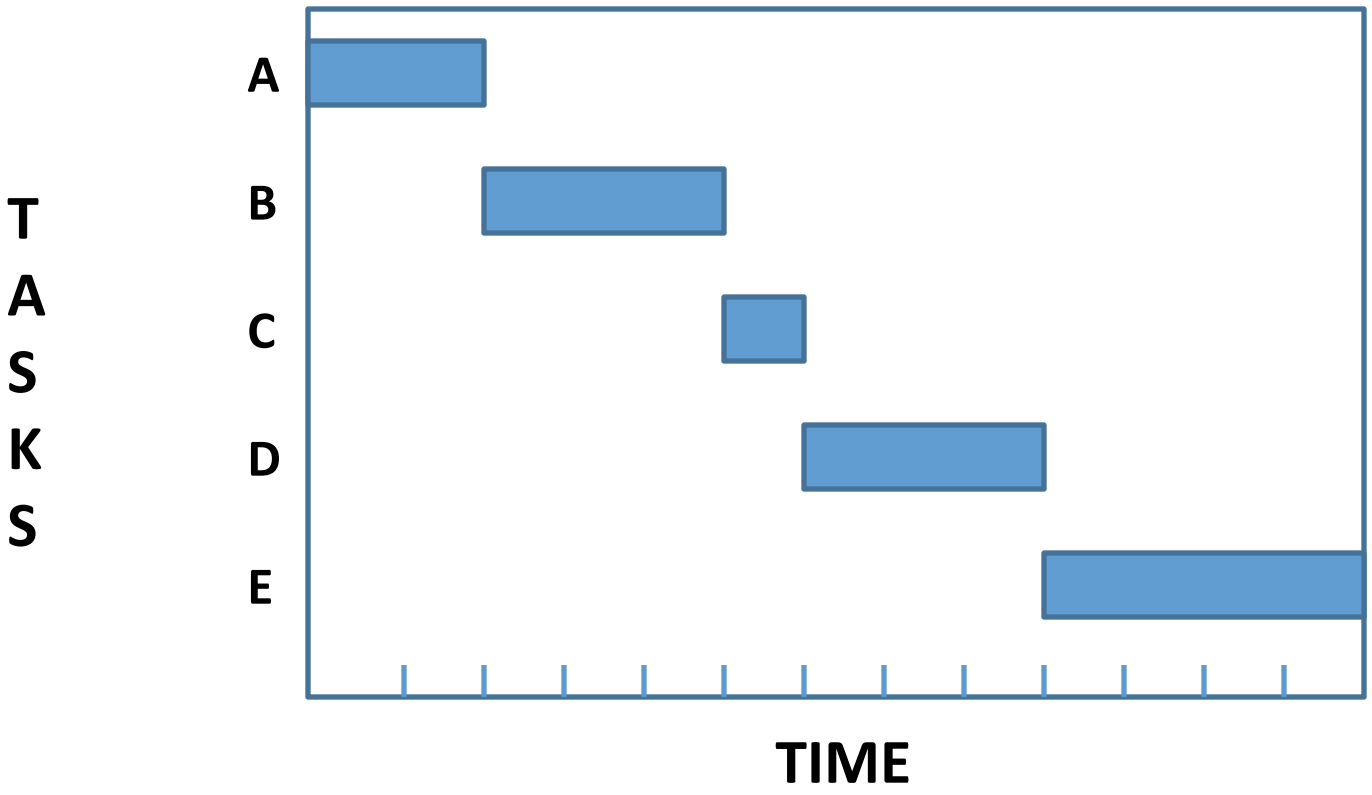
- Identify the tasks that need to be completed.
- Specify the order of the tasks.
- Specify the dependencies of the tasks.
- Estimate the duration of each task.
- Identify the intermediate deadlines.

Research Plan: Gantt Chart

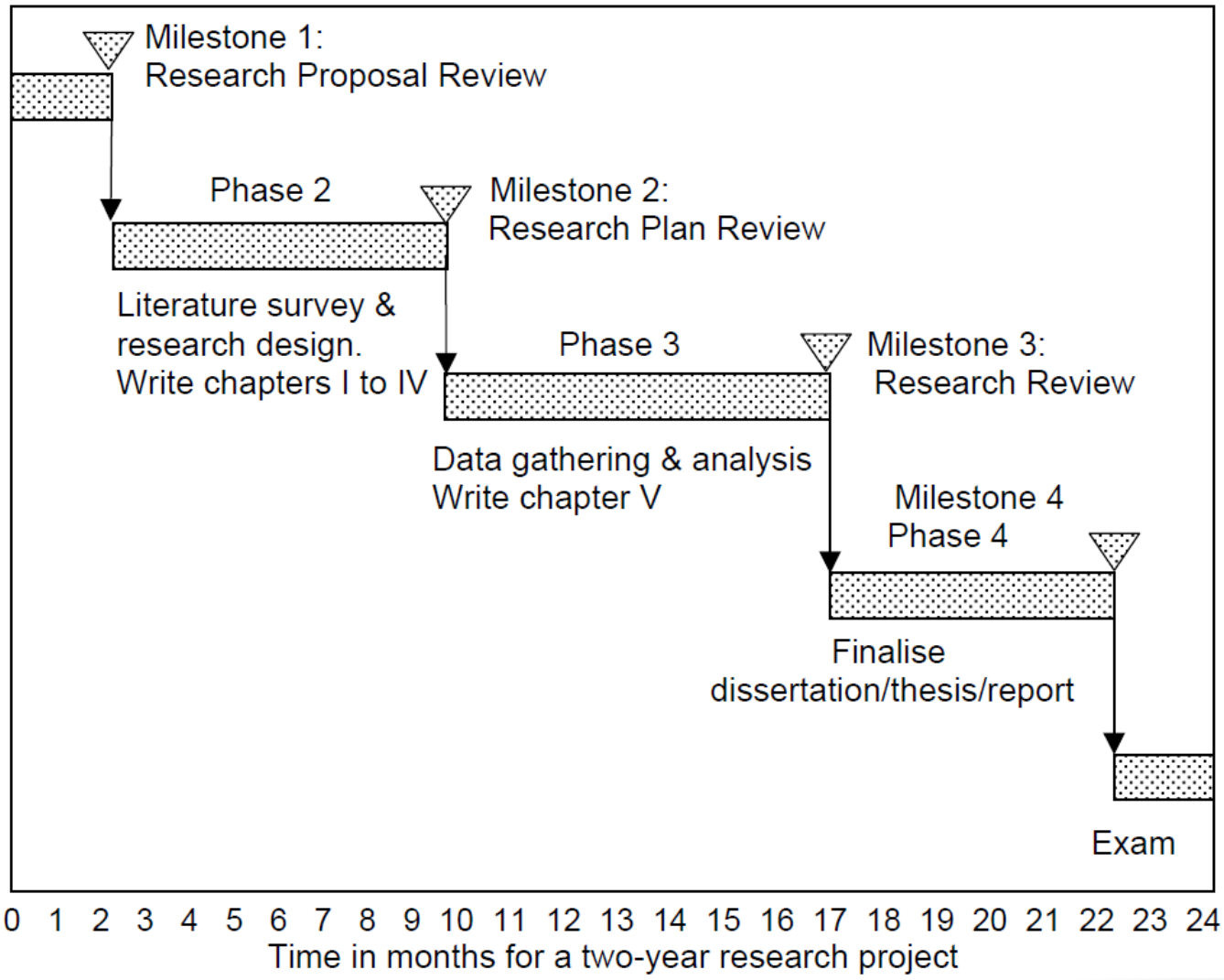
- Gantt chart is a graphical planning/scheduling tool that is easy-to-do and commonly-used.

- The basics of Gantt chart is:
  - The horizontal axis is time.
  - The vertical axis is the tasks.
  - Bars show duration of tasks.
  - Triangles show milestones
  - Dashed lines show dependencies

Simple Gantt Chart



Thesis Plan


Milestone 1:
Research Proposal Review
Phase 2
Milestone 2:
Research Plan Review
Literature survey &
research design.
Write chapters I to IV
Phase 3
Milestone 3:
Research Review
Data gathering & analysis
Write chapter V
Milestone 4
Phase 4
Finalise
dissertation/thesis/report
Exam
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time in months for a two-year research project

Conclusion and Future Work

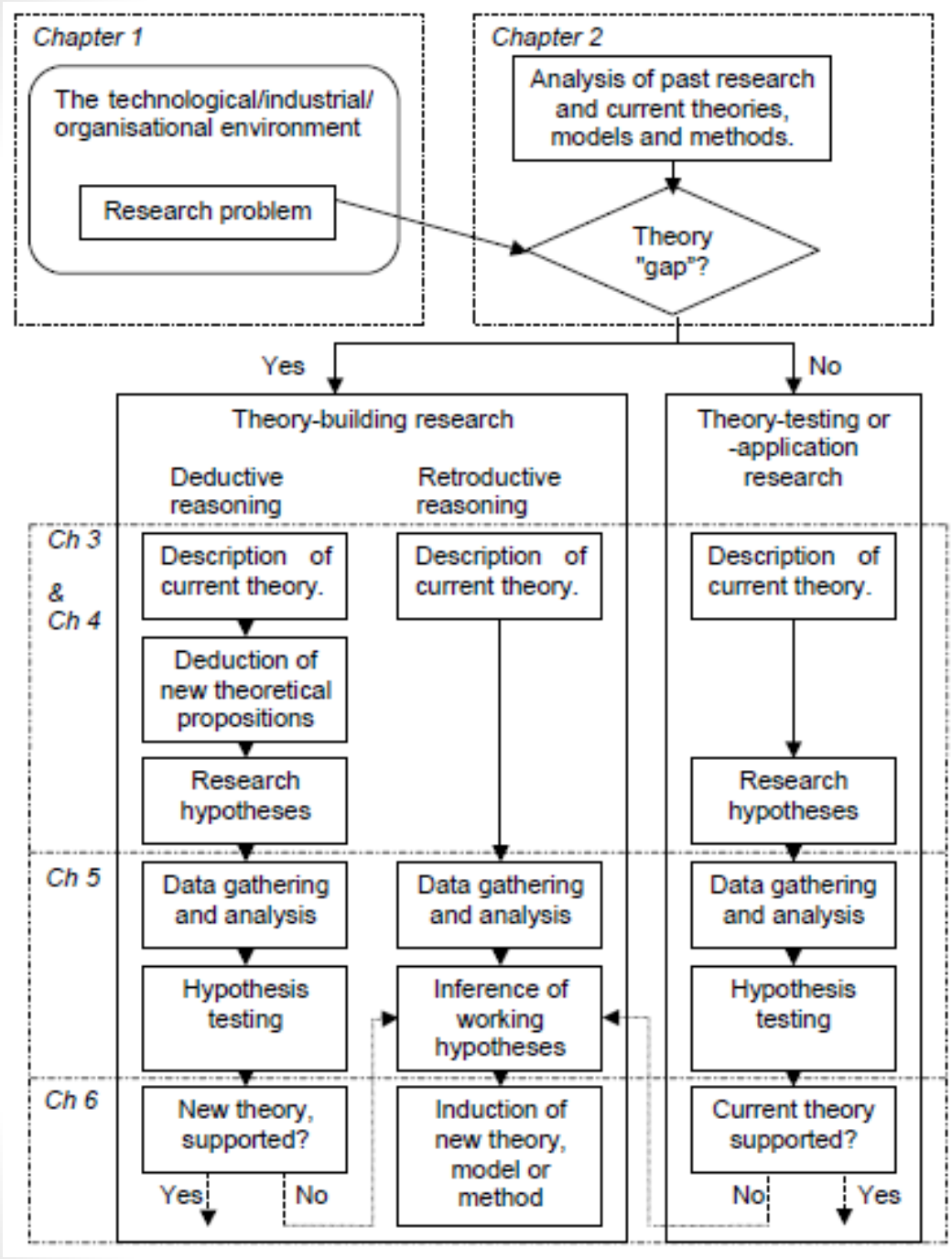
5. Conclusion and Future Work

- Restate your thesis problem
- Summarize your results
  - In a thesis proposal, final results are not available. However, preliminary results might be available
- Identify future work
  - In a thesis proposal, the future work is the work that will be done during the thesis work, such as, developing methods, running experiments, collecting data, and analyzing results

Conclusion/Future Work Example

- This proposal is concerned with developing an intelligent algorithm to optimize the energy in a path planning mission for a mobile robot. The purpose is to develop a fuzzy algorithm that can allow a mobile robot to finish its assigned task while minimizing the energy consumption.

- The algorithm will be tested using Matlab Simulation and lab experiments (using Robotino platform). The results will be collected and compared to a benchmark method.
  - Note must identify the benchmark method to use



RESEARCH LOGIC FOR THEORY-BASED EMPIRICAL RESEARCH

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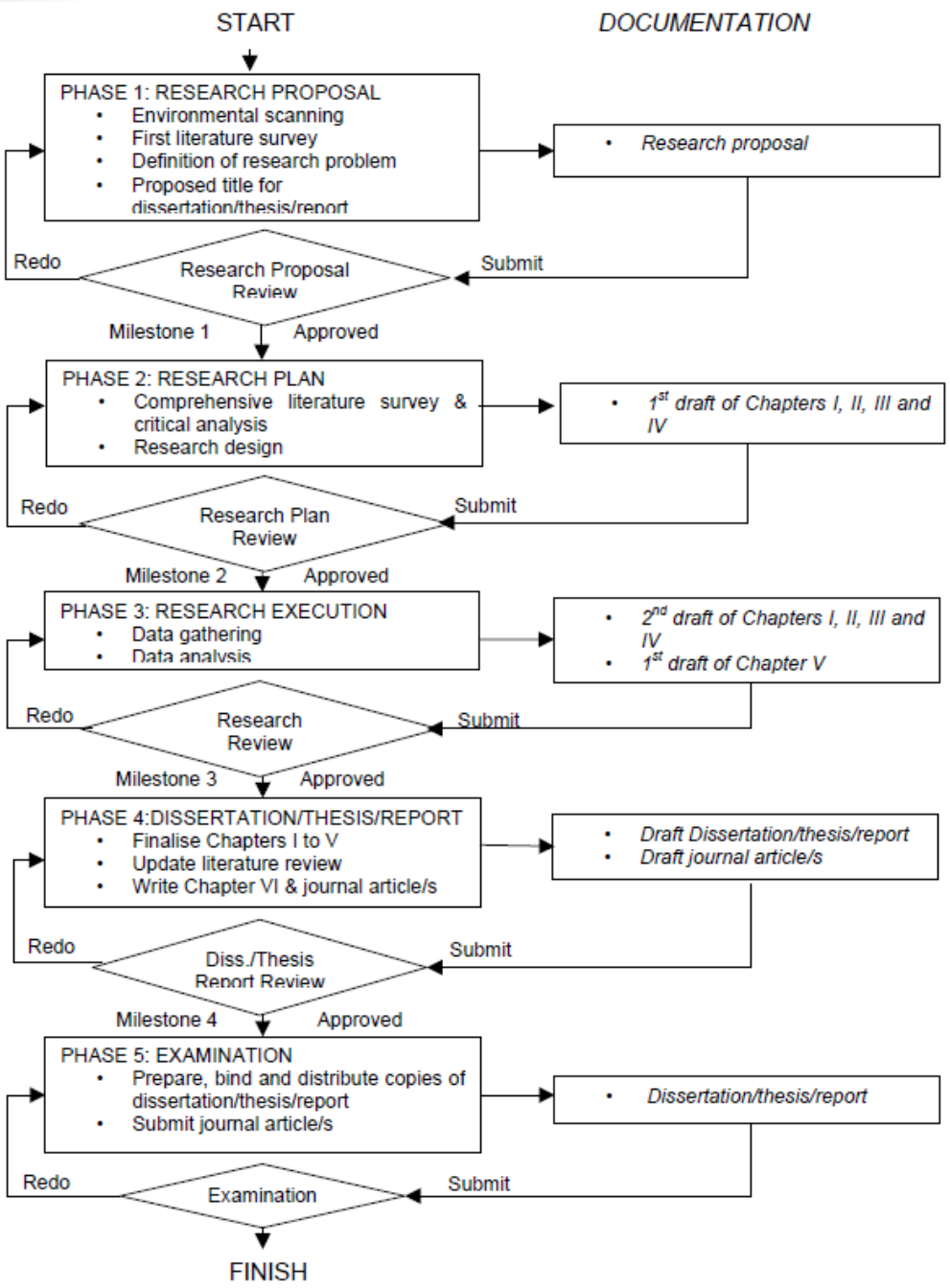
RESEARCH FLOW CHART



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Conclusion

- Research is composed of four phases:
  - Choosing the topic, planning the work, executing the work, and documenting the research work
  - The first two phases, choosing and planning, are parts of the thesis proposal

- Thesis proposal sections are divided into:
  - Introduction, literature review, theoretical background, and research plan

References

1. Research Guide for Post-Graduate Students by Andre Buys. University of Pretoria 2007

2. Models of Dissertation Research in Design by Poggenphl and Sato, Illinois Institute of Technology, USA

3. Scientific Research Methodologies and Techniques by Luis Camarinha-Matos