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Development of an Optical Tracking System for Real-time Robotic Applications

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Abstract

Engineering students often need a clear, practical model for writing dissertations; this document provides an overview tailored to final-year mechatronics projects and demonstrates effective use of a LaTeX thesis template. Many student reports lack consistent structure, rigorous scoping, and appropriate use of figures, tables, code listings, and citations, which impedes readability and assessment.

This work contributes an exemplar that explains what each report section should contain, offers typical subheadings, and embeds working examples of template elements to copy and adapt. The document is implemented in XeLaTeX using the `memoir` class with chapters for Introduction, Literature Review, Methodology, Results, Discussion, Conclusions, Recommendations, and Appendices, along with acronyms and bibliography support; the result is a shareable guide that doubles as a starting point for students to produce professional, evidence-based engineering reports.

How to write an abstract in 5 minutes?

Answer the following questions in narrative form with no more than two sentences per question:

- *What is the background to the project?*
- *What is the problem that is being solved?*
- *What is the contribution of the project to this problem?*
- *What is the main conclusion of the project?*

Contents

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Abbreviations

AGP Art Gallery Problem 4

GA Genetic Algorithm 6

GDOP Geometric Dilution of Precision 4

OCP Optimal Camera Placement 4

Introduction 1

This chapter orients the reader: It describes what the report is about, why it matters, what will be covered, and how the document is organised. Keep it clear, concise and specific to the engineering context. Use forward references to later chapters to help the reader. Keep the Introduction brief; move technical depth to later chapters.

1.1 Subject and motivation for report

State, in one or two sentences, the subject of the report and why it matters to the stakeholder. For example: “This report describes the main sections and features of an engineering report template.” Briefly mention the engineering motivation (performance, cost, safety, reliability, sustainability) and link it to measurable needs or constraints. The first sentence in this section should capture the essence of what this report is about.

1.2 Background to investigation

Provide context that sets the scene for the reader: prior events, relevant standards, existing systems, or operational constraints. Keep this factual and short; defer in-depth theory to the Literature Review (Chapter ??). Figures may be used if they are relevant to the report, for examples in a project on mechatronic design, you may want to introduce the field of mechatronics using a diagram such as Figure

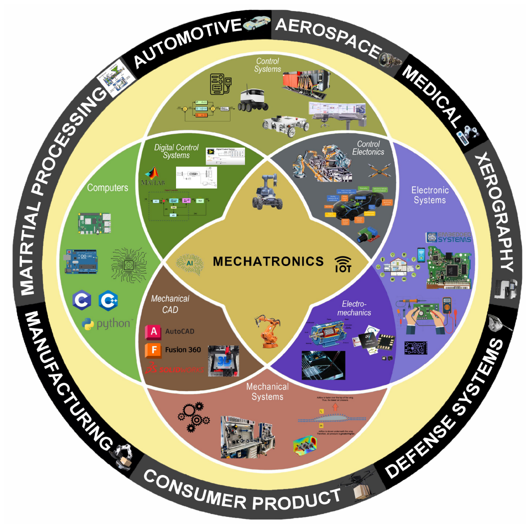

Figure 1.1: The overlap of traditional disciplines comprising the field of mechatronics

Here, it can be seen that mechatronics is an interdisciplinary field that draws on the principles of mechanics, electronics, computer science, and control systems to design and develop intelligent machines and systems. Typically, projects offered by the MechatronicSystems.Group are related to the disciplines within this diagram.

1.3 Objectives of report

State what the report will achieve. Use action verbs and make objectives measurable. For a typical mechatronics project, the specific objectives might be to:

- Design and implement a control system for an autonomous mobile robot capable of obstacle avoidance and path following.
- Develop sensor fusion algorithms integrating, ultrasonic, and camera data for real-time navigation.
- Evaluate system performance through quantitative metrics including positioning accuracy (±5 cm), response time (<100 ms), and reliability (>95% success rate).
- Validate the integrated mechatronic system under controlled laboratory conditions and document design trade-offs.

1.4 Limitations and scope of investigation

Clarify boundaries so the reader knows what is and is not covered. Indicate factors that influenced scope (e.g., time, cost, equipment availability, data access). Note populations, sites, subsystems, or operating conditions included and excluded. Explicitly state assumptions.

Table 1.1: Typical scope boundaries for a mechatronics project; adapt to your specific investigation.

In scope	Out of scope
Indoor navigation on flat surfaces	Outdoor terrain and weather conditions
Obstacle detection and avoidance	Dynamic obstacle tracking
Real-time control at 50 Hz update rate	High-frequency vibration analysis
Laboratory testing environment	Industrial deployment scenarios
Single robot operation	Multi-robot coordination
Basic machine learning algorithms	Deep learning implementations
Prototype-level manufacturing	Production-ready design optimization
Safety systems for laboratory use	Commercial safety certifications

1.5 Plan of development

Explain how the report is organised so the reader can navigate it. This report follows a structured approach that builds systematically from foundational knowledge to practical outcomes. Chapter **??** begins by synthesising relevant prior work and identifying the gap that this investigation addresses. Following this theoretical foundation, Chapter **??** details the methods, data, and validation procedures employed in the study. The empirical findings are then presented in Chapter **??**, which displays results through figures and tables without interpretation, allowing the data to speak for itself. Chapter **??** subsequently interprets these results, comparing them to existing literature and discussing any limitations encountered. The investigation concludes with Chapter **??**, which answers the stated objectives concisely, followed by Chapter **??** that provides actionable recommendations and outlines future work opportunities.

Literature Review 2

The effectiveness of indoor localisation systems depends on the strategic positioning of the sensor network. Depending on the application, the distribution may need to prioritise coverage of a large space with sufficiently distinct viewpoints to capture elaborate motion, or it may need to be configured to mitigate the Geometric Dilution of Precision (GDOP) arising from the sensor network's limited resolution [1]. The placement problem constitutes an optimisation task involving determination of both the quantity and pose of sensors so as to improve measurement quality by minimising the inherent uncertainty. This section explores the principal approaches to the Optimal Camera Placement (OCP) problem, examining both the characterisation of sources of inherent uncertainty, attributable to image quantisation and occlusion of the target, and strategies for addressing them, as well as the range of optimisation methods employed, from heuristic algorithms to integer programming.

2.1 Optimising Camera Placement

The OCP descends from the well-studied Art Gallery Problem (AGP), which investigated the minimum number of guards required to observe an entire 2D polygon with n vertices. The AGP assumed guards had unlimited 360° field of view, infinite range, and operated in two dimensions only. Fisk elegantly proved that $\lfloor \frac{n}{3} \rfloor$ guards are always sufficient to cover any simple polygon, using a proof based on triangulation and 3-colouring; in practice, specific polygons often require fewer, as demonstrated in Figure In this example, a polygon with $n = 13$ vertices is first triangulated, then each vertex is assigned one of three colours such that no triangle shares two vertices of the same colour; placing guards at all vertices of the least frequent colour guarantees complete coverage. The optimal camera placement problem extends this foundation by introducing constraints that reflect the true capabilities and limitations of physical sensors.

These constraints are motivated by diverse applications: surveillance and monitoring [2], motion capture [3, 4], augmented and virtual reality [5], and autonomous driving [6]. In such visual sensor networks, accurate localisation requires that each marker or feature be visible to at least two cameras, enabling 3D position recovery through triangulation [3, 4]. Sensor placement (including amount, location, and orientation) significantly affects system coverage and tracking performance [7]. However, the OCP is NP-hard and combinatorial: the search space grows explosively with the number of candidate positions and orientations, rendering exhaustive search intractable. Consequently, heuristic-based approximation algorithms offer a practical path to acceptable solutions within reasonable computation time.

Generally, the OCP can be stated as follows: given a set of candidate camera locations and orientations, find the configuration that maximises 3D reconstruction quality of a target within a defined workspace, subject to practical constraints such as mounting options and budget. Solving this problem requires balancing trade-offs among coverage, accuracy, and computational efficiency. Without the aid of an optimisation algorithm, the sensors are arranged in an ad-hoc configuration by the designer, which requires expertise or trial and error, which can be time-consuming or sacrificial if a sub-par arrangement is settled on. Thus the resulting localisation error is neither calculated nor considered mathematically. Thus, there is a need to optimise the camera netwrok based on metrics that minimise the effects of resolution degredation and probabilistic occlusion even if the trajectory of the target is not known exactly beforehand.

2.1.1 Optimisation Approaches for Camera Placement

Recent research has explored both how to formulate the problem and when to conclude that an optimal solution has been found. Two primary classes of optimisation methods have emerged: heuristic algorithms and integer programming. The problem formulation typically depends of defining a specific objective function, camera model, and workspace representation. Eventhough the search space is continuous it is typical of designers to discretise both the workspace and the possible camera placements to make the problem more computable. Depending on the application, available resources, and workspace constraints, different optimisation objectives have been prioritised in the literature. Broadly, these can be categorised into coverage-based objectives and accuracy-based objectives. In terms of coverage-based objectives, the goal is to maximise the visible area of the workspace, or to handle aspects of occlusion both static and dynamic. This is particularly relevant in surveillance applications where ensuring that all regions are monitored is critical [2]. Conversely, accuracy-based objectives focus on minimising localisation error, which is crucial in motion capture and augmented reality applications where precise tracking is required and more than one camera arranged sufficiently non-parallel is needed to ensure triangulation is possible [3, 5]. Furthermore, Wu, Sharma, and Huang went further to assess how the limited camera intrinsics and quantisation lead to inaccurate measurements exacerbated by the placement of two cameras [8]. Many studies have proposed hybrid objectives that balance coverage and accuracy, that balance the trade-off of accuracy with coverage [4, 7]. Some works have also considered additional constraints such as budget limits and physical mounting options [3, 6, 9].

Theoretical Development 3

Genetic Algorithms Inspired by the process of natural selection, Genetic Algorithm (GA) are adaptive heuristic optimisation algorithms used to quickly find an optimal solution to search spaces that are large, unsmooth, multi-objective, and ill-defined. They belong to the broader class of evolutionary algorithms which harness the biological mechanisms of selection, crossover (mating), and mutation (diversity) to evolve a population of candidate solutions towards ones that have a higher fitness based on the objective function. Typically, the algorithm begins with a randomly generated population of individuals which are assessed for their fitness. During the selection stage, the fitter individiuals are chosen to, during the process of crossover, combine and produce offspring for the next generation. To ensure diversity in the search space (collection of candidate solutions), mutation is randomly applied to some individuals. This process is repeated over a number of generations until a stopping criterion is met, such as a maximum number of generations or convergence to a satisfactory solution.

GA Terminology

- **Chromosome**:
- **Gene**:
- **Population**:
- **Fitness function**:
- **Generation**:
- **Selection**:
- **Crossover**:
- **Mutation**:

3.0.1 Encoding schemes

difference between binary encoding, gray code, real encoding, permutation encoding, variable length chromosomes

3.0.2 Selection Methods

Fitness proportionate selection: roulette-wheel selection, stochastic universal sampling rank-based selection tournament selection boltzmann selection elitism

3.0.3 Crossover Techniques

single-point crossover double point crossover parameterized uniform crossover

3.0.4 Parameters for GAs

Population size Crossover rate Mutation rate

3.0.5 Advantages over traditional optimisation methods

Methodology 4

The methodology chapter is the technical heart of an engineering report, providing a detailed account of *how* the investigation was conducted. This chapter serves as a blueprint that enables other engineers to understand, evaluate, and potentially reproduce your work. It bridges the gap between the theoretical foundation established in the literature review and the empirical results that follow.

A well-crafted methodology demonstrates engineering rigor through systematic approaches, justified design decisions, and transparent documentation of procedures. It establishes credibility by showing that results were obtained through sound engineering practices rather than ad-hoc experimentation. The methodology also provides the framework for interpreting results and assessing their validity and reliability.

4.1 Purpose and Scope of Engineering Methodology

The methodology chapter fulfills several critical functions in engineering documentation:

- **Reproducibility**: Provides sufficient detail for independent verification and replication of results.
- **Validation**: Demonstrates that methods are appropriate for addressing the stated objectives.
- **Transparency**: Documents assumptions, limitations, and potential sources of error.
- **Justification**: Explains why specific approaches were chosen over alternatives.
- **Quality assurance**: Shows adherence to relevant standards and best practices.
- **Risk management**: Identifies and addresses potential failure modes or uncertainties.

4.2 Typical Structure and Content

An effective engineering methodology typically includes the following elements, adapted to your specific investigation:

- System overview and requirements specification.
- Experimental design and test planning.

- Hardware and software architecture.
- Data collection and preprocessing procedures.
- Analysis methods and computational models.
- Validation and verification protocols.
- Quality control and uncertainty quantification.

4.3 System Overview and Architecture

Begin with a clear description of the overall system or approach. Use block diagrams, flowcharts, or system architecture figures to illustrate key components and their relationships. Define system requirements, performance specifications, and design constraints. This establishes the criteria against which your methodology will be evaluated.

4.4 Implementation Details

Document the specific tools, platforms, and configurations used. Provide sufficient detail for reproduction while maintaining focus on engineering-relevant specifications. For example, use tables to summarise technical specifications as shown in Table **??**, below.

Table 4.1: Key hardware and software specifications for system implementation.

Component	Specification
MCU	120 MHz Cortex-M4F
Sensor	± 2 g MEMS accelerometer
OS	Ubuntu 22.04 LTS
Language	C/C++ and Python

4.5 Procedures and Protocols

Present step-by-step procedures with specific parameters, tolerances, and measurement protocols. Reference relevant standards and best practices, such as calibration procedures per [**phad**]. Include:

- Detailed experimental procedures.
- Measurement protocols and instrumentation.
- Data collection parameters (sampling rates, duration, conditions).
- Quality control checkpoints.
- Error handling and exception procedures.

4.6 Data Processing and Analysis Framework

Describe your approach to data processing, analysis methods, and computational models. Include mathematical formulations where appropriate, such as the efficiency calculation:

$$\eta = \frac{P_{\text{out}}}{P_{\text{in}}}. \tag{4.1}$$

Document preprocessing steps, filtering approaches, and analytical techniques. Explain the rationale for chosen methods and any assumptions made.

4.7 Validation and Verification

Outline procedures for ensuring result validity and system verification. This might include:

- Calibration and measurement validation.
- Cross-validation techniques.
- Sensitivity analysis.
- Comparison with theoretical predictions or benchmarks.
- Statistical significance testing.

4.8 Assumptions and Limitations

Explicitly state all significant assumptions and acknowledge methodological limitations. This transparency strengthens rather than weakens your work by demonstrating awareness of constraints and potential sources of uncertainty. The methodology should demonstrate that your approach is systematic, rigorous, and appropriate for addressing your stated objectives while acknowledging the practical constraints within which the work was conducted.

Results 5

The results chapter presents the empirical findings of your engineering investigation in an objective, factual manner. This chapter serves as the foundation for subsequent analysis and interpretation, providing the raw evidence that supports your conclusions. The primary purpose is to document what was observed, measured, or produced during your investigation without editorial commentary or theoretical interpretation.

Effective results presentation in engineering reports requires clarity, precision, and systematic organisation. Data should be presented with appropriate statistical measures, uncertainty quantification, and clear visual representations. This chapter establishes the credibility of your work through transparent reporting of both successful outcomes and unexpected findings, including any limitations or anomalies encountered during data collection.

5.1 Purpose and Principles of Results Presentation

The results chapter fulfills several critical functions in engineering documentation:

- **Objective documentation**: Present findings without bias, interpretation, or speculation.
- **Quantitative evidence**: Provide measurable data with appropriate precision and units.
- **Systematic organisation**: Structure results logically to support the investigation objectives.
- **Transparency**: Report all relevant findings, including unexpected results or limitations.
- **Reproducibility**: Present sufficient detail for independent verification.
- **Statistical rigor**: Include uncertainty measures, confidence intervals, and sample sizes.

5.2 Typical Structure and Content

An effective engineering results chapter typically includes the following elements, organised to align with your methodology and objectives:

- Data quality assessment and validation results.
- Primary experimental or computational findings.

- Performance metrics and comparative analyses.
- Secondary results and sensitivity studies.
- Observed anomalies, outliers, and error characterisation.
- System validation and verification outcomes.

5.3 Data Quality and Validation

Begin by establishing the reliability and completeness of your dataset. Report data collection success rates, calibration results, and any preprocessing steps applied. This builds confidence in subsequent findings and demonstrates engineering rigor.

Document measurement uncertainties, systematic errors, and the effectiveness of quality control procedures implemented during data collection. Reference specific validation protocols from your methodology chapter.

5.4 Primary Results

Present your main findings using appropriate tables, figures, and quantitative summaries. Ensure all data includes proper units, significant figures, and uncertainty estimates. Use clear, descriptive captions that allow figures and tables to be understood independently.

Table 5.1: System performance comparison showing key engineering metrics with measurement uncertainties.

Metric	Baseline	Optimised Design	Improvement
Efficiency (%)	85.0 ± 1.2	91.2 ± 0.8	+7.3%
Response Time (ms)	12.3 ± 0.5	9.7 ± 0.3	-21.1%
Power Consumption (W)	2.5 ± 0.1	2.1 ± 0.1	-16.0%
Reliability (MTBF, hrs)	1250	1680	+34.4%

5.5 Anomalies and Limitations

Document any unexpected findings, outliers, or deviations from predicted behaviour. Report equipment failures, data collection issues, or procedural variations that may have affected results. This transparency strengthens rather than weakens your work by demonstrating awareness of limitations.

The results chapter should provide a complete, unbiased record of your investigation's outcomes, establishing the empirical foundation for the analysis and interpretation that follows in the discussion chapter.

Discussion 6

The discussion chapter transforms raw results into engineering insights by interpreting findings within the context of your objectives, theoretical framework, and practical constraints. This chapter serves as the analytical bridge between empirical observations and actionable conclusions, where you demonstrate your engineering judgment and critical thinking skills.

Unlike the results chapter, which presents objective findings, the discussion provides subjective interpretation, analysis of causality, and evaluation of engineering trade-offs. This is where you explain *why* certain results occurred, assess their significance relative to design requirements, and explore the broader implications for engineering practice.

6.1 Purpose and Scope of Engineering Discussion

The discussion chapter fulfills several critical analytical functions:

- **Interpretation**: Explain what results mean in engineering terms and practical contexts.
- **Contextualisation**: Compare findings with literature, standards, and industry benchmarks.
- **Causality analysis**: Propose mechanisms and explanations for observed phenomena.
- **Trade-off evaluation**: Assess competing design objectives and performance compromises.
- **Limitation assessment**: Critically evaluate constraints and validity boundaries.
- **Engineering judgment**: Apply professional expertise to assess practical significance.

6.2 Typical Structure and Content

An effective engineering discussion typically addresses the following elements, tailored to your specific investigation:

- Performance evaluation against objectives and requirements.
- Comparison with prior work and established benchmarks.

- Analysis of design trade-offs and optimisation outcomes.
- Sensitivity analysis and robustness assessment.
- Identification of failure modes and limiting factors.
- Practical implications for engineering applications.
- Threats to validity and methodological limitations.

Some typical subsections of the discussion chapter are:

6.3 Performance Analysis and Requirements Assessment

Begin by evaluating your results against the original objectives and system requirements established in earlier chapters. Quantify how well your solution meets performance specifications and identify areas where targets were exceeded or not achieved.

For example, if Table **??** from your results chapter shows efficiency improvements of 7.3%, discuss whether this meets your design targets, how it compares to theoretical predictions, and what factors contributed to this performance level.

6.4 Comparative Analysis and Benchmarking

Compare your findings with relevant literature, industry standards, and competing approaches identified in your literature review. This contextualises your work within the broader engineering landscape and demonstrates awareness of alternative solutions.

Discuss how your results advance the state of practice, identify novel contributions, and highlight areas where your approach offers advantages or faces limitations compared to existing methods.

6.5 Engineering Trade-offs and Design Decisions

Analyse the engineering trade-offs inherent in your design choices. Discuss how optimising one performance metric may have affected others, and evaluate whether the overall balance aligns with your design priorities.

For instance, improvements in efficiency might come at the cost of increased complexity, higher material costs, or reduced reliability. Assess these trade-offs in the context of your application requirements and user needs.

6.6 Sensitivity and Robustness Analysis

Examine how sensitive your results are to variations in key parameters, operating conditions, or assumptions. This analysis helps establish the reliability and practical applicability of your findings under real-world conditions.

Discuss the robustness of your solution to manufacturing tolerances, environmental variations, or usage patterns that differ from your test conditions.

6.7 Limitations and Validity Assessment

Critically evaluate the limitations of your methodology, assumptions, and results. Discuss potential sources of error, uncertainty, or bias that may affect the validity of your conclusions.

Address threats to internal validity (experimental design issues) and external validity (generalisability limitations). This demonstrates engineering maturity and helps readers appropriately interpret and apply your findings.

6.8 Evidence-based Interpretation Guidelines

Maintain rigorous connection between claims and evidence throughout your discussion:

- Reference specific results (e.g., Table **??**) to support interpretations.
- Avoid introducing new data; focus on analysing existing results.
- Propose mechanisms and explanations grounded in engineering principles.
- Distinguish between correlation and causation in your analysis.
- Acknowledge uncertainty and alternative explanations where appropriate.

6.9 Summary

The discussion chapter should demonstrate your ability to think critically about engineering problems, synthesise complex information, and provide insights that advance both theoretical understanding and practical application.

Conclusions 7

The conclusions chapter provides a definitive summary of your engineering investigation, synthesising key findings into clear, actionable statements that directly address your original objectives. This chapter serves as the culmination of your technical work, transforming detailed results and analysis into concise engineering insights that demonstrate the value and impact of your investigation. As a culmination chapter, no new information should be introduced at this stage, rather it should be focussed on summarising the key findings and their implications.

Unlike the discussion chapter, which interprets and analyses findings, the conclusions chapter presents definitive statements about what has been achieved, learned, and demonstrated. It provides closure to the engineering narrative by explicitly answering the research questions posed in your introduction and quantifying the extent to which objectives have been met.

7.1 Purpose and Structure of Engineering Conclusions

The conclusions chapter fulfills several critical functions in engineering documentation:

- **Objective fulfillment**: Explicitly state how each original objective was addressed.
- **Key findings synthesis**: Distill complex results into clear, actionable insights.
- **Engineering value**: Quantify improvements, innovations, or contributions achieved.
- **Practical impact**: Demonstrate real-world applicability and significance.
- **Knowledge advancement**: Identify how your work extends engineering understanding.
- **Honest assessment**: Acknowledge limitations and areas for future development.

Some typical subsections of the conclusions chapter are:

7.2 Summary of Key Findings

Present your most significant findings as clear, evidence-based statements. Each conclusion should be directly traceable to results presented earlier and should quantify achievements where possible. For example:

- System efficiency was improved by 7.3% compared to baseline design, exceeding the target improvement of 5%.
- Response time was reduced by 21.1%, meeting the sub-10ms requirement for real-time applications.
- Power consumption decreased by 16.0%, contributing to extended operational lifetime.
- Reliability increased by 34.4% as measured by mean time between failures.

7.3 Contributions to Engineering Practice

Identify the specific contributions your work makes to engineering knowledge and practice. This might include:

- Novel design approaches or methodologies developed.
- Performance improvements achieved through innovative solutions.
- Validation of theoretical models or design principles.
- Identification of optimal operating parameters or design configurations.
- Development of tools, frameworks, or procedures for future use.
- Insights into failure modes, limitations, or design trade-offs.

7.4 Objective Achievement Assessment

Systematically address each objective stated in your introduction, providing a clear assessment of achievement level:

- **Objective 1**: [State objective] - *Fully achieved* through [brief summary of how].
- **Objective 2**: [State objective] - *Partially achieved* with [quantified results and limitations].
- **Objective 3**: [State objective] - *Exceeded expectations* by [quantified improvements].

7.5 Limitations and Scope Boundaries

Acknowledge the boundaries of your investigation and areas where objectives were not fully met. This demonstrates engineering maturity and helps readers understand the appropriate context for applying your findings:

- Scope limitations imposed by time, resource, or access constraints.
- Technical limitations of methods, equipment, or approaches used.

- Assumptions that may limit generalisability of results.
- Areas where further investigation is needed for complete understanding.
- Trade-offs accepted to achieve primary objectives.

7.6 Engineering Impact and Significance

Conclude by articulating the broader significance of your work for engineering practice, industry applications, or future research directions. Quantify the potential impact where possible and identify specific contexts where your findings could be applied.

The conclusions chapter should leave readers with a clear understanding of what has been accomplished, what it means for engineering practice, and how the work contributes to advancing the field.

7.7 Summary

The conclusions chapter should demonstrate your ability to synthesise complex findings, articulate practical implications, and provide clear, actionable guidance for future work.

Recommendations 8

The recommendations chapter translates your engineering findings into actionable guidance for implementation and future development. This chapter serves as the practical bridge between technical conclusions and real-world application, providing stakeholders with clear direction for next steps based on evidence from your investigation.

Unlike conclusions, which summarise what was achieved, recommendations focus on what should be done next. This chapter demonstrates engineering judgment by prioritising actions based on technical merit, feasibility, and potential impact while acknowledging resource constraints and implementation risks.

8.1 Implementation Recommendations

Present specific, actionable recommendations for applying your findings in practice. Each recommendation should include:

- Clear description of the proposed action or change.
- Technical justification based on your results.
- Expected benefits and performance improvements.
- Implementation requirements and resource needs.
- Potential risks and mitigation strategies.
- Priority level and timeline considerations.

For example: “Implement the optimised control algorithm to achieve the demonstrated 7.3% efficiency improvement, requiring firmware updates and 2-week validation testing."

8.2 Future Work

Identify high-impact opportunities for extending your investigation, prioritised by potential value and feasibility. Focus on:

- Critical gaps that emerged from your limitations analysis.
- Promising research directions suggested by your findings.
- Validation studies needed for broader application.
- Scaling considerations for different operating conditions.

- Integration challenges with existing systems.

Provide sufficient detail for others to understand the scope and approach for each recommended investigation, while maintaining focus on engineering priorities rather than academic completeness.

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Miscellaneous Technical Writing Standards A

Unfortunately, there are many technical writing pseudo-standards that are expected by the academic and professional world. This appendix provides examples of some of these standards which should be followed in your writing.

A.1 Figures

Figures should be used anywhere in the report where they may be valuable, except for the Abstract. Figures should be used to *supplement the text*, not replace it. Figures should be used to *illustrate the text*, not to explain it. Figures should be used to *make the text more readable*, not to make the text more complex. Therefore, no figure should stand alone in your report. Every figure should be introduced in the text before it appears and referenced in the text afterwards (if relevant). Every figure should also be labeled with a caption. Please see the example in Figure **??** in Chapter **??** for how this was done there.

A.2 Tables

Tables follow the same rules as figures. Every table should be introduced in the text before it appears and referenced in the text afterwards (if relevant). Every table should also be labeled with a caption. However, for tables, the caption should be placed at the top of the table, not the bottom. Please see the example in Table **??** in Chapter **??** for how this was done there.

A.3 Acronyms

Acronyms should be used consistently throughout the report. Every acronym should be defined in the text before it is used and should also be placed in the List of Acronyms. For example, in a project on UAV control, “Inertial Measurement Unit" might be a commonly used set of words. This could be abbreviated to “IMU" for the sake of brevity. However, if this abbreviation is used consistently throughout the report, then it should be defined in the text before it is used. For example, “An Inertial Measurement Unit (IMU) is a sensor that measures the angular velocity and acceleration of a vehicle." After being defined, the acronym should be used in the text consistently thereafter, except for in headings, where the full name should be used.

A.4 Units

The S.I. system mandates that the unit for a quantity be placed one space after the numerical value. For an example distance measurement, “10 m" is correct, but “10m" is not. Notable exceptions to this rule are angles, where the degree symbol is used, and percentages, where the percent symbol is used.

A.5 Equations

Equations that find a use more than once in a report should be labeled with a unique identifier. This identifier should be placed in parentheses after the equation, and should be used in the text to refer to the equation. For example,“The efficiency of the system is given by the equation (**??**) in Chapter **??**."

Further, equations should be centered and properly aligned. This is important for readability and clarity. They also form part of sentence in which they are introduced, and so grammatical rules should be followed dependent on their position in the sentence. I.e. they should be followed by a period if they are the last part of a sentence, and by a comma if they are not the last part of a sentence.

A.6 Paragraphs

A single sentence is not a paragraph and should be avoided.

A paragraph is a group of sentences that are related to a *single topic*. The first sentence of a paragraph should be a clear and concise statement of the topic. The subsequent sentences should develop and support this topic.