

Project Proposal MaxJ 2305556

by Max Jones

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Simulating Vehicle Traction for Game
Implementation
Research Proposal

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1224 Words

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1. Introduction

1 Modelling vehicle dynamics plays a vital role in recreating a realistic driving experience in both tailored racing games and open world games, the feeling of driving and how realistic it is can significantly influence a player's immersion. In game development there is a need to marry both realism and efficiency due to the fact that games must run in real time[1].

2 This project explores how current real-world vehicle dynamic models can be adapted to be used within the game industry. While there is significant research already conducted within the automotive and engineering industries which accurately simulate these dynamics [2] there is a lot less attention on translating these models to make them more efficient for real-time entertainment applications.

3 The motivation behind this project lies within bridging the gap between scientific vehicle dynamics and game development to enhance player immersion. By researching, developing, and testing different traction models within industry standard game engines, this study aims to contribute insight for creating responsive and believable driving experiences without needing excessive computational power.

2. Background to the Proposed Research

Vehicle dynamics simulations are a fundamental part of replicating realistic driving behaviours. These simulations need to be computationally efficient enough so they can be executed in real-time environments which means that they are typically more gutted down and bare bones than the fully realistic simulations used in vehicle engineering.

In recent years, there has been a growing focus on creating real-time capable vehicle dynamics tailored more towards gaming. Archut [3] provides a systematic review of contemporary methods for achieving real-time vehicle simulation, noting strategies such as model-order reduction, look-up tables, and semi-empirical simplifications. These approaches enable faster-than-real-time simulation but often at the cost of reduced fidelity. Other studies have shown that by separating parts of the vehicle's movement for example, the up-and-down motion from the forward motion simulations can be made faster while still looking realistic [4]. Similar work has been done for off-road driving, where tyres interact with uneven terrain or loose surfaces like mud or sand [5].

Artificial intelligence is also starting to play a role. Machine learning models can predict how a vehicle will behave on complex roads in real time, combining traditional physics equations with data-driven prediction [6]. This makes it possible to keep realistic handling while avoiding heavy calculations.

Despite all these advances, there's still a clear gap when it comes to bringing physically accurate vehicle models into everyday game engines like Unity or Unreal Engine. The vehicle physics systems built into these engines are designed to run fast, but they simplify or ignore important effects such as tyre friction changes, load transfer, or wheel slip [7]. Because of this, driving in many games feels believable but not truly realistic.

The plan is to design a traction model which is a simplified but realistic way of simulating tyre grip and weight distribution that balances physical accuracy with speed. The model will be based on proven engineering theories, like Pacejka's tyre equations [2], but adapted to work efficiently in real time. Tests will measure how accurate and efficient the model is, and a user study will find out whether players think it feels more realistic than standard game physics.



By combining recent advances in real-time vehicle modelling, adaptive physics, and AI-assisted prediction, this project hopes to create a middle ground between engineering-grade simulation and fast, responsive gameplay. The results could help developers build games, training simulators, and educational tools that feel more authentic without sacrificing performance.

3. Research Problem statement

In today's games the vehicle simulations will often prioritise being visually realistic over being physically accurate, this leads to unrealistic handling under a variety of conditions. There is a lack of models which balances creating realistic handling while being lightweight enough to real-time performance. This project addresses this problem by researching and developing an efficient vehicle traction model that can be implemented in modern game engines.

4. Research Aim & Objectives

Aim:



To research, design, and implement an optimised yet accurate vehicle dynamic model that can be used in modern game engines which balances realism and efficiency.

Objectives:

1.  Conduct a literature review of existing models.
2. Develop a simplified yet grounded simulation using established vehicle dynamics principles.
3. Implement the model within an industry standard game engine (Unity or Unreal Engine)
4. Evaluate the model for accuracy, computational performance, and perceived realism.
5. Produce documentation detailing the design, implementation, and the evaluation.

5. Methodology

5.1 Methods

The research conducted in this project will follow an experimental software development approach. The methodology will combine elements of software design, prototyping, implementation, data collection and evaluation.

The model will be designed using equations for traction, friction, and weight transfer. The experimental testing will be conducted using controlled scenarios in a yet to be

selected game engine. The quantitative data such as acceleration and braking distances which will be collected from the testing will be recorded and compared to existing published benchmarks. The evaluation of will include metrics such as realism and computational efficiency.

5.2 Materials

The data sources used will be vehicle statistics such as mass and wheelbase which will be obtained through the manufacturer's specifications. The tyre friction coefficients will be based upon Pacejka's magic tyre model and be validated against existing literature.

8 The tools that will be used will include a yet to be chosen game engine (either Unity or Unreal Engine), Git-Hub for version control, MATLAB for data analysis and in-engine telemetry to log the data collected.

9 The project will also use a user study which will compare the proposed model against a baseline physics setup. Participants will perform standardised driving tasks and then answer a questionnaire on the perceived realism of both models.

6 Project Plan

Late October – Finalise project proposal.

Middle November – Design vehicle traction model (Core physics equations)

Middle December – Implement core model into chosen engine.

End of December – Preliminary testing and debugging

Middle January – Interim Viva

February – Refine physics model.

March – Conduct user evaluation

March – Analyse data and interpret results.

April – Complete report

Early May – Final Submission and Final Viva

7. References

- [1] M. Brudnak, "Terrain Streaming for Real-Time Vehicle Dynamics," 2024.
- [2] H. B. Pacejka and I. Besselink, *Tire and vehicle dynamics*, 3rd Ed. Amsterdam ;: Elsevier/BH, 2012.
- [3] J. Archut and B. Corves, "Systematic mapping of methods for real-time capable multibody simulation of road vehicles using PRISMA," *Multibody system dynamics*, 2025. doi: 10.1007/s11044-025-10081-1.
- [4] W. Dai, et al., "Real-Time Modeling of Vehicle's Longitudinal-Vertical Dynamics in ADAS Applications," *Actuators*, vol. 11, no. 12, pp.378, 2022. doi: 10.3390/act11120378.
- [5] A. Peiret, et al., "Modelling of off-road wheeled vehicles for real-time dynamic simulation," *J.Terramech.*, vol. 97, pp.45–58, 2021. doi: 10.1016/j.jterra.2021.04.001.
- [6] L. Paparusso, S. Melzi and F. Braghin, "Real-time forecasting of driver-vehicle dynamics on 3D roads: A deep-learning framework leveraging Bayesian optimisation," *Transportation research.Part C, Emerging technologies*, vol. 156, pp.104329, 2023. doi: 10.1016/j.trc.2023.104329.
- [7] H. Fathi, et al., "Modeling and Validation of a Passenger Car Tire Using Finite Element Analysis," *Vehicles*, vol. 6, no. 1, pp.384–402, 2024. doi: 10.3390/vehicles6010016.

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GRADEMARK REPORT

FINAL GRADE

50 / 100

GENERAL COMMENTS

Biggest point: Make sure your objectives are SMART

Improve the methodology, justify your choice

how do you know when the project is complete?
What's your success criteria?

Timeline was lacking visual sugar

Add more critical analysis to your lit review, i.e.
quantitative comparisons

The core idea is
sound, the literature engagement is good, and the
document is well-presented. The technical
knowledge is clearly there
- it's the methodology and planning detail that needs
development.

Introduction/Aims & Objectives: 9.5/20
Background/Literature Review: 14.5/20
Project Design/Methodology: 9/30
Resources/Planning: 4/15 Document Presentation:
13/15

Total: 50%



Comment 1

Good opening that establishes the domain and identifies the key tension (realism vs efficiency). The tone is appropriately academic and the motivation is clear.



Comment 2

Clear identification of research gap between engineering-grade simulation and game implementation. This sets up the project well.



Comment 3

This introduction section is good, but it is separate from the Aims & Objectives. The marking criteria expects Introduction/Aims/Objectives to be combined into one cohesive section of ~400 words. Your aims and objectives appear much later in the document. Consider restructuring to have: brief intro (2 paragraphs), then aims, then objectives, then deliverables and success criteria - all within 400 words total.



Comment 4

The following three paragraphs (starting 'The plan is to design...') appear to be formatted differently and may not be part of the literature review. If these paragraphs are describing YOUR proposed approach, they belong in the Methodology section, not the Background/Literature Review. The Background should focus on what others have done, not what you plan to do. Please restructure to keep literature review focused on prior work only.



Comment 5

Clear, single overarching aim that is focused and achievable.



Comment 6

MISSING: Success criteria and deliverables.

You need to explicitly state: How will you know if the project succeeded? (e.g., 'Success = achieving ≥ 60 FPS, $\leq 15\%$ error vs baseline, and statistically significant improvement in user ratings'), and What will be delivered? (e.g., 'Working prototype executable, source code on GitHub, final report, demonstration video, user study data').



Comment 7

far too vague

Specify your development methodology with justification. For example: 'Iterative prototyping approach will be used because it allows continuous refinement based on testing results.'

Statistical methods are NOT specified. You mention collecting quantitative data but don't say how you'll analyse it

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Comment 8

Justify your tool choices. Why Unity vs Unreal? Consider: 'Unity Engine 2023 LTS will be used because: (a) C# scripting allows easier integration with MATLAB via .NET interop, (b) WheelCollider component provides suitable baseline for comparison, (c) extensive documentation and community support for vehicle physics, (d) lower GPU requirements enabling testing on mid-range hardware.' Also confirm resource availability: 'Unity license available through university educational programme; MATLAB license confirmed via department'.



Comment 9

User study protocol is completely absent.

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