# \chapter{Introduction}

Road friction is crucial to traffic safety. Winter roads can be challenging since the conditions may change rapidly. One of the most abrupt factors for people and businesses in the Arctic region is the closing of main roads due to trailer trucks in need of rescue.

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Most of the previous works on road friction and its correlation with traffic safety has been focusing on the risk of accidents ~\citep{Friction}. But closing of a road reasoned by a trailer truck needing rescue because it was unable to ascent a hill causes cascading problems for the community. For example, it affects the abilities to clean the roads for snow, salting or sanding, and assisting for rescues. This in turn makes the roads less safe and thus increases the risk of accidents.

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A simulation could help predict the chances of a trailer truck being unable to ascent a hill. This could potentially reduce the yearly resources needed to rescue these trailer trucks tremendously.

## \section{Relevance}

It is not an uncommon occurrence that trailers are unable to ascent hills and stops traffic. The local newspaper Fremover, have documented several rescue cases involving trailers unable to ascent hills due to winter roads. ~\citep{Treldal} and ~\citep{Taraldsvikbakken} is both such cases. A thesis like this can help lay the groundwork and potentially help create a fully functional simulation. This simulation could predict whenever you as a truck driver may be able to ascent with your current equipment or not. With further research it could even help tell the drivers if they need to put on chains or change their driving style.

## \section{Problem description}

The main purpose of this thesis is to research the possibility of creating a realistic simulation of trailer trucks trying to ascent a hill. This includes creation a demo and evaluate its accuracy. How the effects of adjusting some of the variable parameters can be shown, and to which extent does the trade-off between complexity and simplicity affect the uncertainty of the model is also an important aspect of the research. For example, is a simplified model still useful and/or relevant?

## \section{Inputs and variable parameters}

There are several variables needed to be taken into consideration when creating the simulation. The road condition, the truck model and hill steepness are some of the basic variables we need for a working simulation. The main factors regarding variables are the complexity and realism of the simulation. A complex and correct friction calculation can give a more realistic result, but a demo might never be finished.

### \subsection{Accuracy}

The accuracy of the simulation is heavily reliant on how good the compensation for the inaccuracy and range of the parameters are. Both the friction coefficient and the trailers acceleration are parameters with a potentially high inaccuracy, as well as a great influence on the end result.

## \section{Friction}

As mentioned earlier, the friction estimation and calculation are important aspects of the simulation. Where even a slight change of the friction coefficient can change the result tremendously. There are two main approaches for friction estimation, model-based and experiment-based approach ~\citep{frictionEstimation}.

### \subsection{Model-based approach}

Model-based approaches contains all the methods using mathematical or dynamical models to estimate the friction. The lack of requirements for any specialized sensor and the repeatability of the results in most cases, makes the model-based approach more used than the experiment-based approach.

\begin{table}[H]

\footnotesize

\center

\begin{tabular}{|p{0.22\linewidth} p{0.22\linewidth} p{0.22\linewidth} p{0.22\linewidth}|}

\hline

Pavement Surface

Characteristics &

Vehicle Operating

Parameters &

Tire Properties &

Environment \\ [0.5ex]

\hline \hline

Microtexture & Slip speed & Foot Print & Climate \\

Macrotexture & - Vehicle speed & Tread design and condition & - Wind \\

Megatexture & - Braking action & Rubber composition and hardness & - Temperature \\

Unevenness & Driving maneuver & Inflation pressure & - Water (rainfall, condensation) \\

Material properties & - Turning & Load & - Snow and Ice \\

Temperature & - Overtaking & Temperature & Contaminants \\

& & & - Anti-skid material (salt, sand) \\

& & & - Dirt, mud, debris \\ [1ex]

\hline

\end{tabular}

\caption{THIS IS CAPTION}

\end{table}

### \subsection{Experiment-based approach}

Figure~\ref{fig:FlowChartExperiment} demonstrates the main philosophy behind experiment-based approach. The majority of experiment-based methods used sensors for measuring the friction-related parameters, and then try to correlate these parameters to tire-road friction.

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\begin{figure} [H]

\centering

\begin{tikzpicture}

% draw rectangle node

\node[draw,

minimum width=2cm,

minimum height=1cm,

text width=3cm,

text centered] (block1) {

Measurements of friction-related parameters

};

\node[draw,

minimum width=2cm,

minimum height=1cm,

right=of block1,

text width=3cm,

text centered] (block2) {

Find correlation between measured data and friction

};

\node[draw,

minimum width=2cm,

minimum height=1cm,

right=of block2,

text width=3cm,

text centered] (block3) {

Estimate the friction

};

% Arrows

\draw[-latex] (block1) edge (block2)

(block2) edge (block3);

\end{tikzpicture}

\caption{Experiment-based flowchart diagram.}

\label{fig:FlowChartExperiment}

\end{figure}

There are three main types of sensor types used for experiment-based approaches, optical sensors and cameras, acoustic sensor, and tire tread sensors. The optical sensors and cameras are used for detecting surface properties related to friction. The acoustic sensors are used for classifying the road surface type and condition. These sensors can determine whenever the road is wet dry, asphalt, concrete, etc. based on the tire noise. The tire tread sensors are used to monitor the interaction between the tire and the road, estimating the deflection of tread elements inside the contact patch.

## \section{Scope and limitations}

Going to write about what trailer the simulation is based on and why.

%Method

# \chapter{Method}

Due to the complexity and the amount of work needed to get an acceptable calculated friction coefficient, it is decided to base it on measured values rather the calculated. The measured values are collected from both an official report from the Norwegian Public Roads Administration ~\citep{vegvesene}, and experiments orchestrated specifically for this thesis.

## \section{PyBullet}

PyBullet ~\citep{coumans2022} is a Python module for physics simulation mainly used for games, robotics and machine learning. While PyBullet is made for python, it is still based on Bullet which is a C++ library. With PyBullet it is possible to create a linked multi body object with the help of basic shapes such as boxes, spheres, cylinders, etc, or load in an already made urdf file ~\citep{urdf}. PyBullet also supports several important features needed for a simulation like this, such as friction and forces on an object with both even and uneven weight distribution.

## \section{Theoretical setup}

### \subsection{Buckingham **\pi** theorem}

### \subsection{State system}

## \section{Experiments }