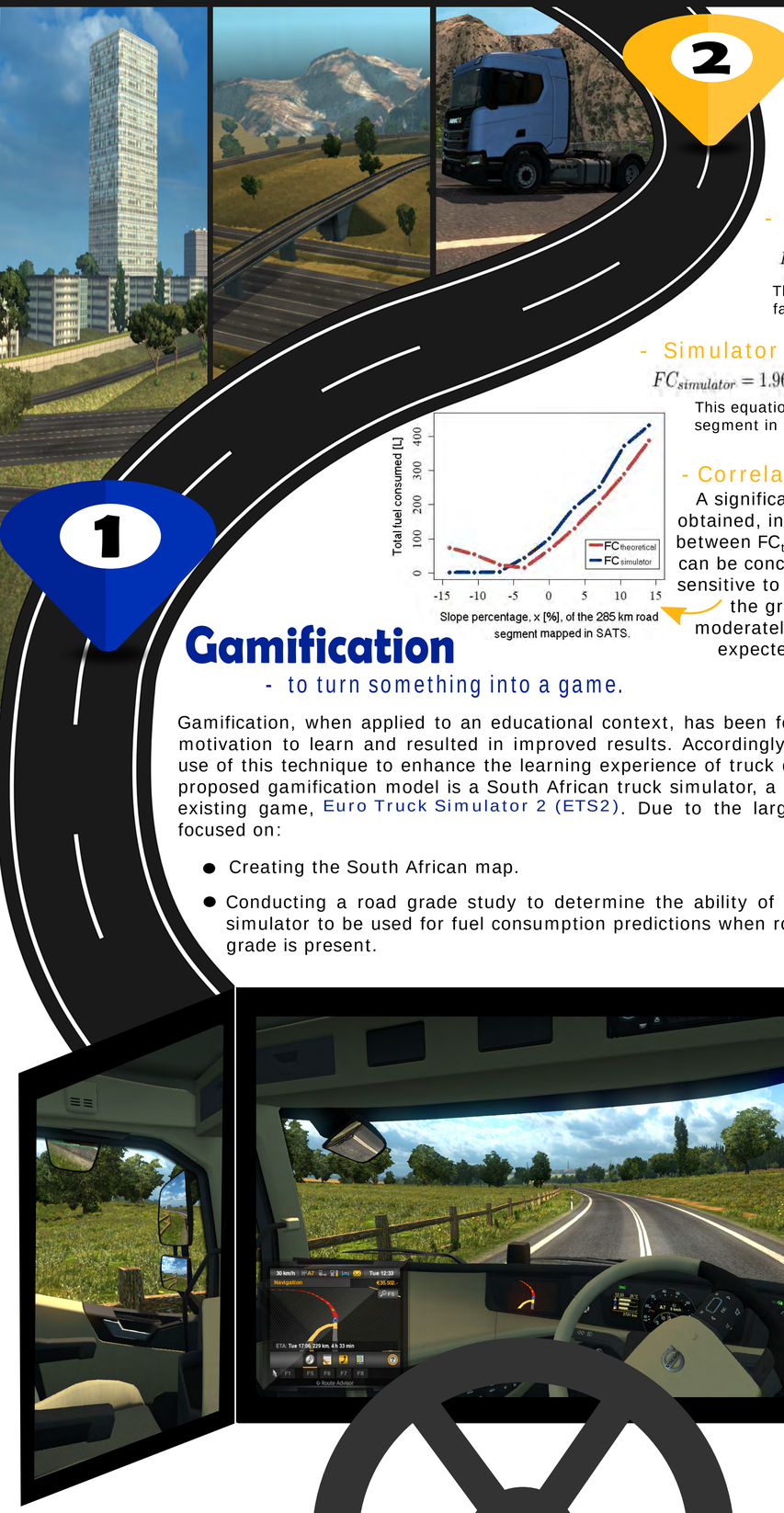
can the South African Truck Simulator be used for elevation-based fuel predictions?



1 Gamification

- to turn something into a game.

Gamification, when applied to an educational context, has been found to improve the user's motivation to learn and resulted in improved results. Accordingly, this project proposes the use of this technique to enhance the learning experience of truck driving in South Africa. The proposed gamification model is a South African truck simulator, a South African version of an existing game, Euro Truck Simulator 2 (ETS2). Due to the large scope, this project only focused on:

- Creating the South African map.
- Conducting a road grade study to determine the ability of the simulator to be used for fuel consumption predictions when road grade is present.

Euro Truck Simulator 2

In this game, a player must deliver various cargo across a realistic depiction of Europe using a truck.

2 Road grade study

The study consisted of nine road segments with an equal base length of 285 km and varying slope percentages, x. The truck traversing the segments is loadless, weighting between 16-32 tonnes and has a constant speed of 60km/h.

To obtain a conclusion, the theoretical fuel consumption ($FC_{theoretical}$) for each road segment was compared with the output of the simulator ($FC_{simulator}$) when simulating a drive on these segments.

- Theoretical fuel consumption

$$FC_{theoretical} = 62.79201\sqrt{1+\left(\frac{x}{100}\right)^2} \times \left|1.194710 + 0.286847x + 0.00785x^2\right|$$

This equation was derived from literature and includes the distance travelled, the load correction factor and the road gradient correction factor (RGCF). The RGCF was obtained by fitting a line of best fit through four benchmark points calculated from literature.

- Simulator fuel consumption

$$FC_{simulator} = 1.96 \times Odometer_{end-value} \times \text{Fuel average consumption}_{end-value}$$

This equation uses two output obtained when simulating a drive on a segment in the simulator. The factor of 1.96 ensures that the desired upwards trend and correct scale is obtained.

Slope percentage, x [%], of the 285 km road segment mapped in SATS.

- Correlation test result

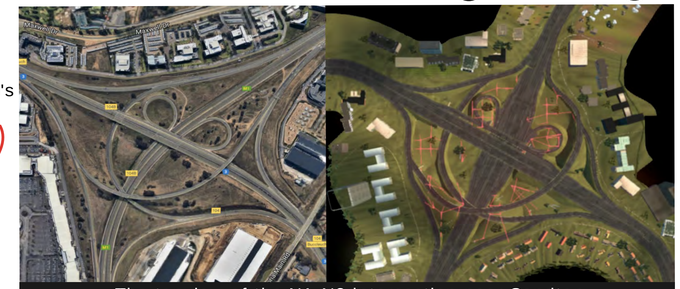
A significant correlation value of 0.965 was obtained, indicating a strong linear relationship between $FC_{theoretical}$ and $FC_{simulator}$. Accordingly, it can be concluded that the simulator's output is sensitive to road grade. Also, as observed from the graph, the output of $FC_{simulator}$ is moderately accurate when compared to the expected fuel consumption, $FC_{theoretical}$.

3 The South African map

The country's main road network was identified and mapped using Euro Truck Simulator's build-in map editor. The editor has various component libraries, such as roads and terrains, that can be used to construct intricate road networks.

Special attention was given to each intersection to ensure that it is a realistic representation of its real-life counterpart. This included the proper positioning and ensuring correct elevation of each intersection. To aid with positioning, a background image of South Africa's road network was included in the editor which was used to trace each route being mapped.

South Africa's main road network



The topview of the N1-N3 intersection near Sandton
left: obtained from Google Earth; right: mapped in the game

4 Simulating drives on the N3

A realistic scenario to validate output results.

Due to the inclination difference of approximately 1600 m between Durban and Johannesburg, the direction of travel on the N3 will influence the journey's fuel consumption. Simulating both directions and using the obtained outputs and $FC_{simulator}$, resulted in the following:

Simulating a drive:

Uphill from Durban to Johannesburg resulted in a fuel efficiency of **2.72 km/L**

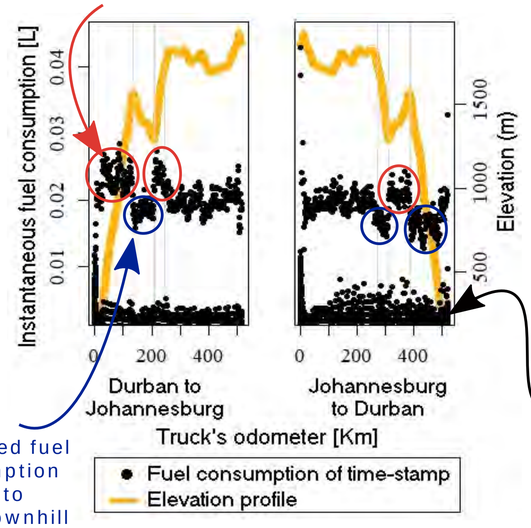
vs.

Downhill from Johannesburg to Durban resulted in a fuel efficiency of **2.92 km/L**

More efficient, as expected!

The difference in fuel efficiency is visually explained when observing the graphed instantaneous fuel consumption (IFC) of each simulated journey. The IFC was obtained by reverse-engineering the simulator's FAC-output.

Increased fuel consumption due to steep uphill



Decreased fuel consumption due to steep downhill

Results validation

The fuel efficiencies obtained from industry are 1.97 km/L for the uphill journey and 1.87 km/L downhill. The simulator's efficiencies are slightly higher due to the optimal environment of the simulation runs: the simulations where conducted at a constant speed of 60km/h, thereby minimizing the amount of acceleration and deceleration. The simulator's outputs therefor provide a reasonably accurate best-case scenario.

Improvement recommendation

Improve fuel predictions by understanding why this is happening and what effect it has on the $FC_{simulator}$ equation.

Conclusion

YES, it can!

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