Temasek Defence Systems Institute

PREDICTION OF MOBILITY PERFORMANCE FOR MILITARY VEHICLE USING FUZZY LOGIC

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Introduction

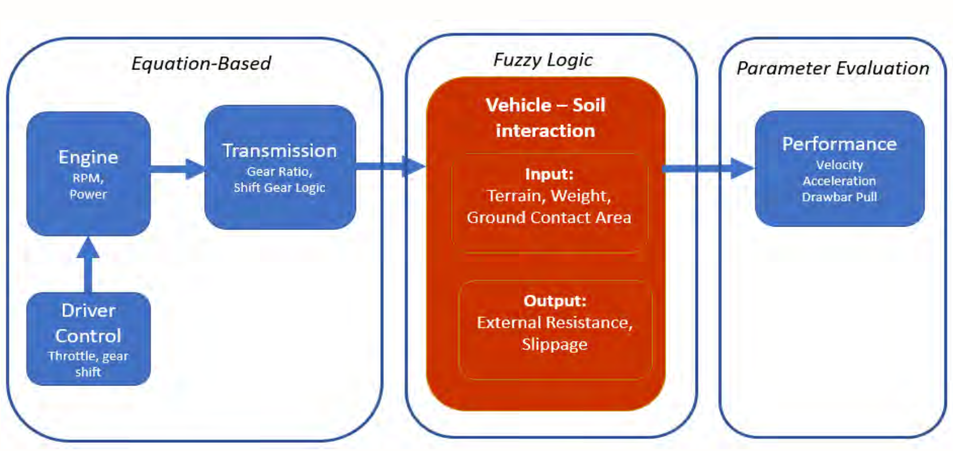
- Conventional mobility assessment required complex analytical method.
- Difficult to replicate actual behaviour of system such as vehicle-soil interaction.
- Use of fuzzy logic can simplify modelling by the use of expert's experience.

Objective

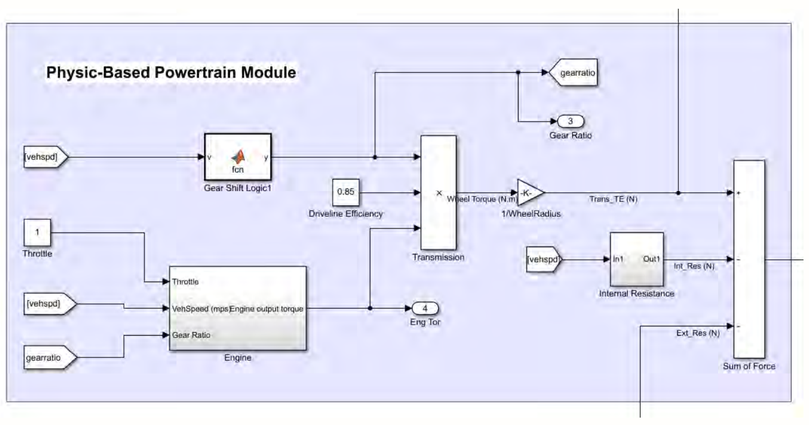
- Demonstrate feasibility of hybrid modelling using analytical and fuzzy-logic for mobility prediction on sandy terrain.

Approach

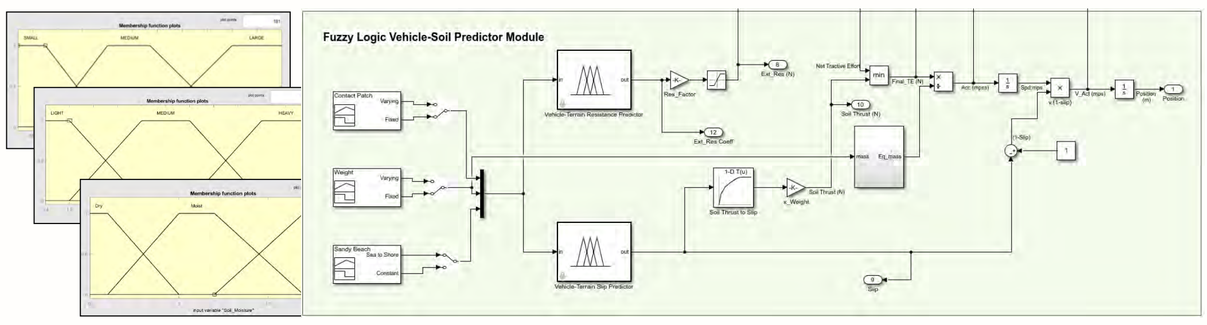
- MATLAB/SIMULINK is used to build this hybrid mobility model consisting of Equation-based Powertrain Model and Fuzzy Logic Vehicle-Soil Interaction Model



- Equation-based Powertrain Model premised on equation of motion with data from engine performance, driveline gear ratio, gear shift logic and wheel parameter.



- Fuzzy Logic Vehicle-Soil Interaction Model consist of a inference system that relates Input to the output through expert experience.



- Performance evaluation and analysis conducted based on various terrain and vehicle conditions.

Fuzzy Inference System

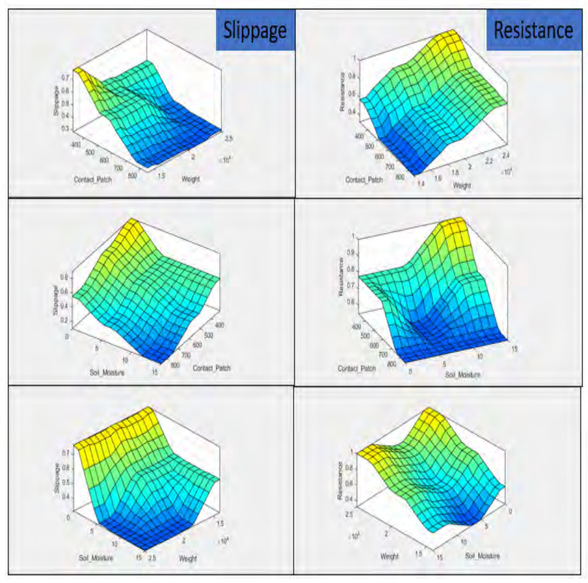
- Key attributes *(vehicle weight, contact patch and terrain condition)* used as input to produce output such as *resistance of motion and wheel slippage* that describle mobility performance.
- 27 Fuzzy IF-ELSE rules set in the Fuzzy Interference System based on expert's experience, knowledge and theory. General relationship between input and output are formed.

S/N	Terrain	Weight	Contact Patch	Resistance	Slip
				VL, L, M, H, VH	VL, L, M, H, VH
1	Dry	Unladen	Small	M	VH
2	Dry	Unladen	Medium	M	H
3	Dry	Unladen	Large	L	M
4	Dry	Normal	Small	H	VH
5	Dry	Normal	Medium	H	H
6	Dry	Normal	Large	M	M
7	Dry	Combat	Small	VH	H
8	Dry	Combat	Medium	VH	H
9	Dry	Combat	Large	H	M
10	Moist	Unladen	Small	M	H
11	Moist	Unladen	Medium	L	M
12	Moist	Unladen	Large	L	L
13	Moist	Normal	Small	H	M
14	Moist	Normal	Medium	M	M
15	Moist	Normal	Large	M	L
16	Moist	Combat	Small	VH	M
17	Moist	Combat	Medium	H	L
18	Moist	Combat	Large	H	L
19	Wet	Unladen	Small	H	H
20	Wet	Unladen	Medium	M	M
21	Wet	Unladen	Large	L	L
22	Wet	Normal	Small	VH	M
23	Wet	Normal	Medium	H	L
24	Wet	Normal	Large	M	VL
25	Wet	Combat	Small	VH	L
26	Wet	Combat	Medium	VH	L
27	Wet	Combat	Large	H	VL

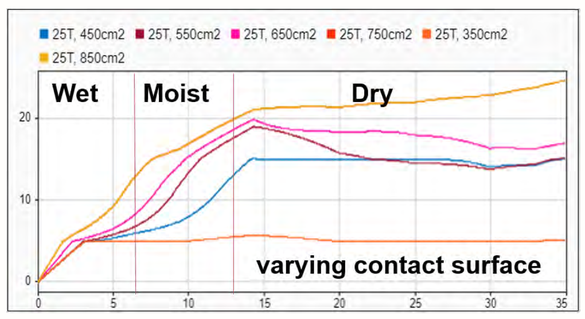
Table 4-1: Fuzzy Logic Rule Set for Resistance and Slippage Predictor

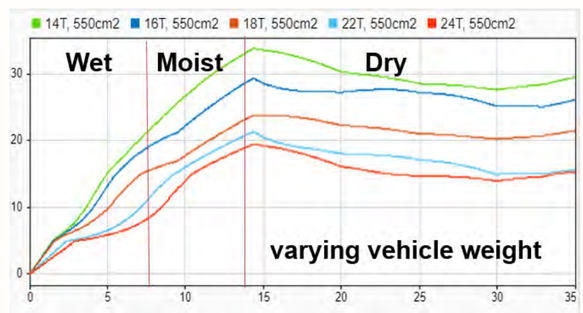
Fuzzy Logic Results

- Relationship of input and output of inference system is consistent with expert rules.
  - High slippage -> low weight and small contact area OR dry soil
  - High resistance -> heavy weight and soil is too dry or wet



Performance Analysis





- With varying contact surface -> 25T from wet to dry sand shows velocity improved with increased contact surface.
- With varying vehicle weight -> Increase weight caused deacceleration and lower max velocity.

Conclusion

- FL modelling is easy to use and adhere to theory and the expert's experience.
- Further improvement to the studies are (1) Use of experiment data for fuzzy interference system, (2) direct performance predictor, (3) expansion to tracked vehicle and various soil condition.

NUS National University of Singapore