A Gradient-based Sensitivity Analysis Method for Complex Systems

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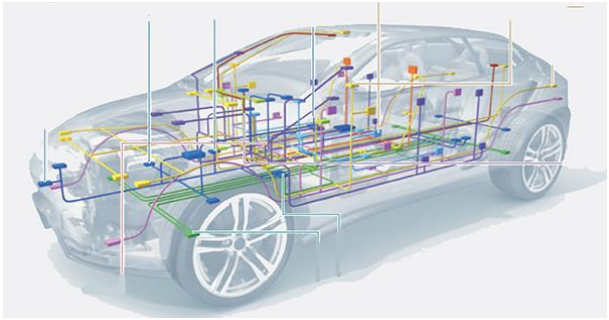
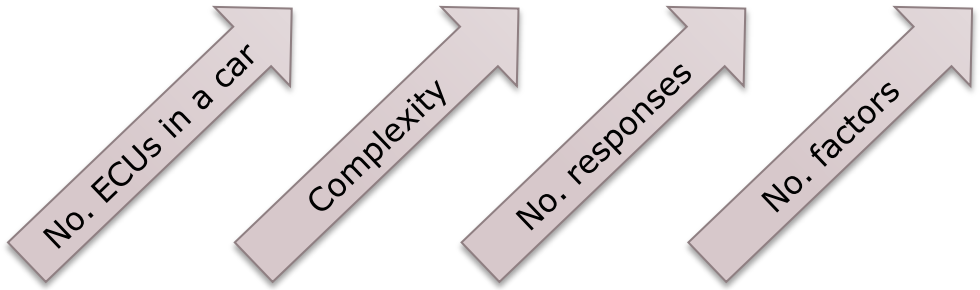
1. Motivation

Technical field: ***Verification***





At different verification stages one must account for:

- Input stimuli
- Process variations
- Operating conditions
- Design parameters

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- Verification becomes expensive
- Verification becomes difficult

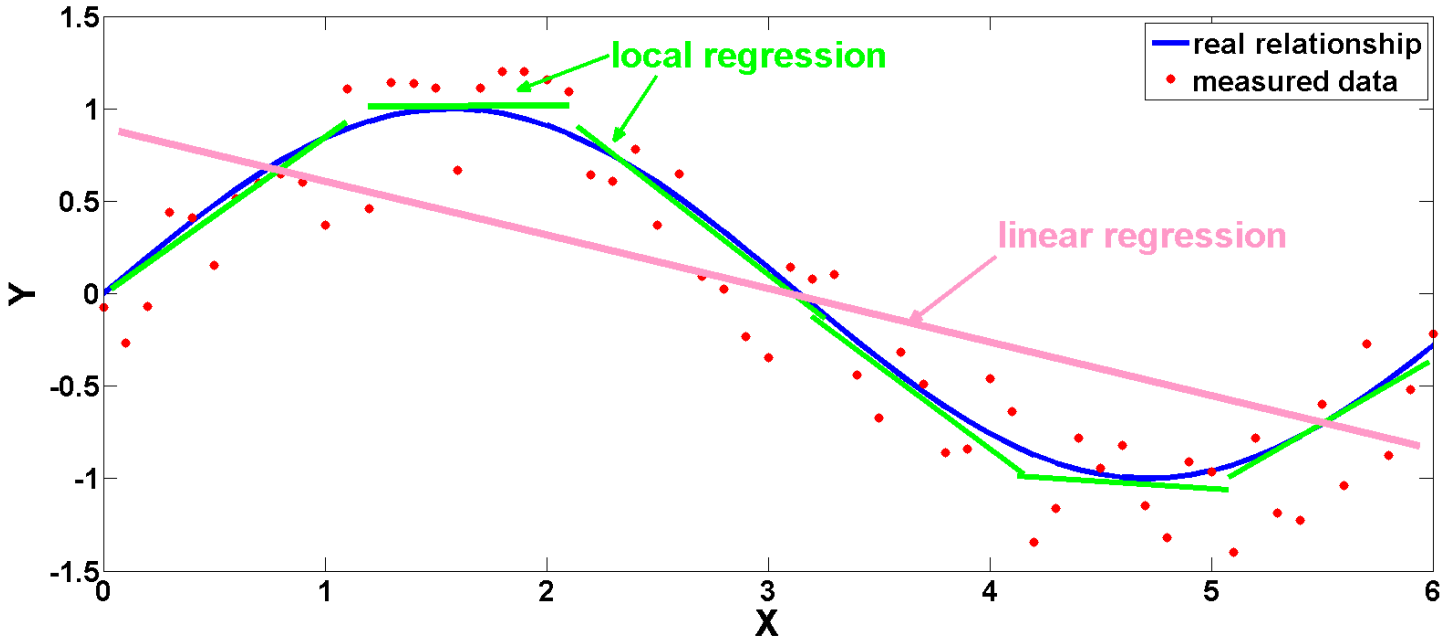
- …but, only a few a factors have impact on the response
- Purpose: appoint the variation of a response to the factors

- Benefits of sensitivity analysis (SA):
- Reduction of the verification space (lower costs)
- Failure/effect discovery
- Increased understanding of the product or the system

2. Proposed SA method

Principle:

- The response-factors function is a hyper-surface in the multidimensional space, which for a local small region of the factor space can be approximated with a plane
- The plane will be tangent to the surface and its orientation is given by the gradient of the surface in that region
- The orientation of the gradient itself indicates the factors that cause variation in the response



3. Validation of the proposed method

- Validation on an electronic system, which is an E-Bike application with 15 factors
- Measured responses: Acceleration time (*AccTime*), Torque Ripple (*TorqueRipple*)
- Approach for validation of the proposed methods on a real system:

1. Take a state-of-the-art method as true reference of input-output sensitivities: (EFAST method)
2. Apply the proposed SA method on the simulation results of the EFAST method's experimental setup
3. If possible, prove that the proposed method has the same accuracy even for a lower number of simulations

Table: Top of most important factors; *AccTime* response

EFAST(975 runs)		Gradient (975 runs)		Gradient (300 runs)	
factor	**S_{Ti}**	**factor**	**He_i**	**factor**	**He_i**
Wref	0.629	*HumanInertia*	0.268	*HumanInertia*	0.412
Ke	0.228	*Ke*	0.107	*Ke*	0.154
GainA	0.073	*GainA*	0.098	*GainA*	0.149

4. Conclusions

Advantages of the proposed gradient-based SA methods:

- ✓ Better accuracy: Proved compared to the EFAST state-of-the-art method
- ✓ Less tests required: similar accuracy as EFAST method even with much lower simulations
- ✓ More factors does not mean more tests
- ✓ No experiment plan imposed: the simulation results of the EFAST method were re-used for the gradient-based method

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