Establishing Adaptive Engagement Criteria for Electronic Stability Control Systems

VEHICLE DYNAMICS FORUM 2008, MICHIGAN

Murat Okçuoğlu

Adaptive Engagement Criteria for Electronic Stability Control Systems

- This presentation will discuss adaptive intervention strategies and techniques for electronic stability control system software to maximize efficiency and effectiveness of such systems

Adaptive Engagement Criteria for Electronic Stability Control Systems

ESC=ESP=DSC=VSC=VDC=PSM=DTSC=StabiliTrak=AdvanceTrac= …

- Electronic Stability Control Systems are known by many names
- In this presentation, I will refer to them as ESC

Adaptive Engagement Criteria for Electronic Stability Control Systems

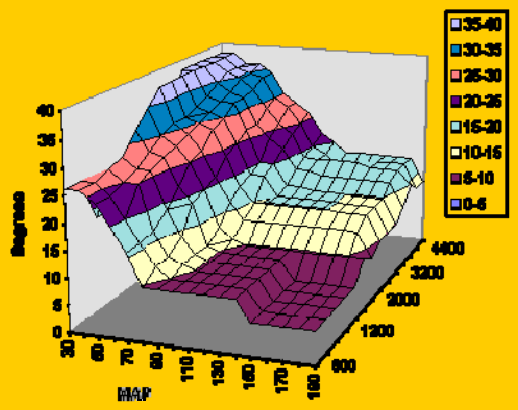
Part I: THE VEHICLE

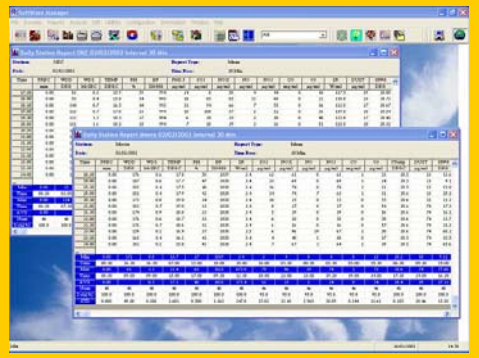
- Initial calibration of ESC has limitations in optimizing braking performance and limit maneuver stability

- Initial ESC calibration must satisfy requirements for all possible range of conditions

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Proper ESC calibration with aggressive intervention settings may conflict with driver comfort concerns





Adaptive Engagement Criteria for Electronic Stability Control Systems

- ESC calibration may end up compromised to accommodate variances in overall vehicle options and condition such as system tolerances, suspension variances, different tires, tire wear, suspension degradation

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Task - Detect vehicle limits and capabilities based on historical sensor patterns
- Mission - Long term trim change allows optimization to vehicle equipment and repair state

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Start aggressive – back up in increments when unnecessary interventions are detected
- Use a different strategy than standard intervention for minimizing driver disruption

Adaptive Engagement Criteria for Electronic Stability Control Systems

- DIFFERENT INTERVENTION STEPS
  - Use shorter brake interventions with subtle, limited and sparingly used engine torque intervention

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Adaptive calibration – Master table modified with an incrementally shifting long term trim

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Asymmetric calibration shift
  - slow to deviate from initial calibration
  - quick to revert to initial calibration
  - *i.e.* vehicle may have been serviced

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Store sample trim tables for quick retrieval in case of reverting to a prior pattern –snow tires

Adaptive Engagement Criteria for Electronic Stability Control Systems

Part II: THE ENVIRONMENT

- Initial calibration of ESC has limitations in optimizing braking performance and limit maneuver stability

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Compromises for weather conditions – must satisfy requirements for all surface conditions

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Task - Detect surface friction coefficient and road risk based on subtle sensor patterns, including ambient sensors and clues (windshield wipers, headlamps)

- Mission – Provide short term trim change to ESC calibration, optimizing for surface friction characteristics and road risks

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Adaptive calibration – Master table modified with a swiftly changing temporary trim

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Rapidly changing short term calibration trim
- Eager policies based on short term trends
- Small step trim shift based on mid term trends

Adaptive Engagement Criteria for Electronic Stability Control Systems

- System will revert to default calibration once the friction pattern is no longer detected

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Asymmetric calibration shift
  - Quick to make trim changes for worst case
  - Slow to revert to initial calibration
  - Conditions may be non-homogenous, intermittent

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Store trim tables for quick retrieval in case of reverting
  - Snow trim table
  - Rain trim table
  - Gravel trim table

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Detect surface type by comparing static coefficient of friction with dynamic coefficient of friction

$$\mu_{static} < \mu_{dynamic}$$

Adaptive Engagement Criteria for Electronic Stability Control Systems

Part III: THE DRIVER

- Initial calibration of ESC has limitations in optimizing braking performance and limit maneuver stability

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Compromises for driver style and skill – must satisfy requirements for all drivers mandate to err on the safe side.

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Task - Detect driver demands, establish personalized criteria
- Mission - Temporary trim change allows optimization for driver preferences

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Adaptive calibration – Master table modified with a rapid changing temporary trim
- Rapid changing short term calibration trim
- Eager policies based on short term trends

Adaptive Engagement Criteria for Electronic Stability Control Systems

- System will revert to default calibration at ignition cycle
- Store trim tables for quick retrieval when same patterns are detected

Adaptive Engagement Criteria for Electronic Stability Control Systems

- Allow drivers to store and retrieve trims

Adaptive Engagement Criteria for Electronic Stability Control Systems

LOW COST HIGH VALUE REFINEMENT

- Current vehicle electronic systems offer the engineers vast potential and opportunities for improving safety, providing utility and delivering owner satisfaction without the typical hardware costs

Adaptive Engagement Criteria for Electronic Stability Control Systems

Adaptive Engagement Criteria for Electronic Stability Control Systems

Thank You!

Murat@cox.net

Murat Okçuoğlu