SAFERIDER Project  
SAFERIDER  
Advanced Rider Assistance Systems  
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ARAS: Advanced Rider Assistance Systems

- Speed Alert
- Curve Warning
- Frontal Collision Warning
- Intersection Support
- Lane Change Support
ARAS implementation in SAFERIDER architecture

ARAS Control Module (ACM)

Lane Change Support (LCS)
ARAS Human Machine Interfaces

Smart Helmet
- Head up display
- Haptic pads
- Stereo Audio

Haptic Seat

Haptic Handle & Haptic Throttle

Haptic Glove

Display

Rear view Mirror

Yamaha SAFERIDER

November 5th, 2010 - Final Event & Demonstration - Leicester, UK
ARAS: the Speed Alert function

- Speed Alert
- Curve Warning
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- Intersection Support
- Lane Change Support
Speed Alert: basic concept

- Speed Alert (SA) provides a warning to the rider if the legal speed limit is exceeded.
- Warning severity is determined by the amount the limit is exceeded.
- Requires digital map data that includes the speed limit for each section of road.
Speed Alert: basic concept

- Speed alert operates within the SAFERIDER architecture.
- Sensor data is received on the CAN bus from the VIF and IMU.
- The ACM Scenario Reconstruction and Digital Map modules identify the bike's position and the local speed limit.
- Speed alert determines if a warning is required.
- The HMI Manager applies suitable HMI outputs.
If the limit is exceeded further the critical warning is triggered. A warning at this level latches until speed complies with the legal limit.
ARAS: the Curve Warning

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Curve Warning : Scenario

The motorcycle runs towards a curve. The rider can choose to move only in its own lane or use all the available road. In any case he/she has to choose the proper speed profile.
The proposed Curve Warning (CW) function is based on the concept of comparing the actual rider manoeuvre with a safe reference manoeuvre. The safe **reference manoeuvre** should be a feasible manoeuvre that complies with system dynamics, trajectory constraints and safety criteria in a “human-like” riding style.

The CW module is seen as a *co-pilot* that computes a manoeuvre that takes into account both *vehicles dynamics* and road geometry and mimic human driving style.
For each estimated state of the motorcycle an “optimal” safe plan is computed.

Note: the planned deceleration is not the maximum possible due to friction. In fact, it is compliant with lateral acceleration and roll angle.
Curve Warning: risk calculation and warning

When the rider doesn’t follow the calculated deceleration plan, a 2 levels warning is generated and provided to the HMI manager in order to alert him in the most proper conditions.

Demo video from Pilot Test activities
ARAS: the Frontal Collision Warning

- Speed Alert
- Curve Warning
- Frontal Collision Warning
- Intersection Support
- Lane Change Support
Frontal Collision Warning: scenario

- Road scenario is similar of Curve Warning but with the purpose of avoid collision with obstacles.

- The rider can choose to
  1. follow the obstacle at a safe distance (moving obstacle)
  2. brake to a safe stop
  3. overtake the obstacle

In SAFERIDER the FCW has been limited to the points 1 & 2. The overtake action requires very good accuracy in position and orientation estimation as well as calculation and comparison of two alternative manoeuvres (high computational capability required).
The module evaluates the motorcycle state in order to check whether it is in a safe state. A state is safe if there exists an emergency braking manoeuvre that avoids collision whatever the former vehicle(s) does.

An obstacle warning is issued:

- for **inappropriate speed** when the current vehicle state (velocity) and driver actions (commanded deceleration) are inconsistent with the correct tailing of the vehicles ahead: e.g., approaching a preceding vehicle too fast.
- for **inappropriate distance** (Safe distance warning), when the current vehicle state (distance) is insufficient to avoid a collision, given the human reaction time, should the vehicle ahead brake unexpectedly: e.g., travelling with insufficient headway.
FCW objects detection through the Laser Scanner

March 26th, 2010
2nd Annual Review
Padova, Italy
Additionally to cost functions described for CW, for FCW a time-dependent constraint is added for each obstacles, which force the motorcycle to keep a desired distance (Safe Distance) from the preceding obstacle and it also makes it possible to stop if the obstacle unexpectedly brakes at its maximum deceleration (i.e. the most critical scenario).
ARAS: the Intersection Support

- Speed Alert
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- Intersection Support

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Intersection Support: aim and scenarios

Intersections are among the most important road critical locations for motorcycles, because unexpected obstacles may cut in.

Intersection Support (IS) aims to efficiently warn the rider against possible collisions with fixed or moving obstacles at road intersections.
Intersection Support: Case (A)

The motorcycle is running on a straight road and it has right of way, a stopped vehicle is present at the intersection

- the potentially dangerous location is treated as a context-based safe speed constraint (not a legal speed limit!)
Intersection Support: Case (B)

The motorcycle is running on a straight road and it has right of way, another vehicle is entering in the vehicle lane:

- the vehicle is treated as an obstacle in the lane and either an emergency braking or a following manoeuvre is computed.
- obstacle avoidance maneuver is not considered.

![Diagram showing intersection support case (B)]
Intersection Support: Case (C)

The motorcycle has to stop or give way.

- A stop maneuver is planned

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intersection diagram with stop signs and speed graph
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The Intersection Support has been fully tested on riding simulator by reproducing all the user cases defined.
ARAS: the Lane Change Support

- Speed Alert
- Curve Warning
- Frontal Collision Warning
- Intersection Support
- Lane Change Support
Lane Change Support: scenario

- **Current State:**
  - limited head mobility
  - small size and vibrating rearview mirrors

- **Problem:**
  - limited rearview
  - critical lane change situation

- **Solution:**
  - Lane Change Support
- First Lane Change System for motorcycles
  - Based on radar sensor
Lane Change Support implementation

- **Coordinate Transformation**: transformation in the motorcycle coordinate system
- **Object Selection**: selection of the most critical object on the left side
- **Boundary Checking**: checking of the predefined limits, e.g. minimal and maximal speed of LCS vehicle
- **Object Evaluation**: checking if object is in Dynamic Warning Zone or in Blind Spot Warning Zone and output generation

LCS ECU

Warning State

Object & PTW Data

Demo video from Pilot Test activities
ARAS electronic control units

- Speed Alert
- Curve Warning
- Frontal Collision Warning
- Intersection Support
- Lane Change Support

Speed Alert, Curve Warning, Frontal Collision and Intersection support runs in the ACM (ARAS Control Module).

The Lane Change Support runs in a dedicated electronic control unit supported by another unit for the radar management.
ARAS in SAFERIDER demonstrators

YAMAHA Ténéré

Triumph Sprint by MIRA

November 5th, 2010

Final Event & Demonstration

Leicester, UK
Conclusions

SAFERIDER project has demonstrated the full feasibility and effectiveness of the ARAS functions.

The pilot tests done made possible to collect a large amount of information and feedbacks from test riders that will be very useful for the next steps.

However, even if the results have been very encouraging, still many steps have to be done in the following directions:

• more integration of ARAS functions where all of them are combined in a non confusing way to provide a transparent, continuous and non-invasive support to rider in every condition.
• improve vehicle localization and state estimation → PTW requires specific estimation algorithms different from automotive ones.
• electronics designed for motorcycle specification (few space, high vibrations, low costs, …)
• focusing even more on “rider friendly” human machine interfaces by constantly monitoring the rider needs & feedback
Thank you!