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Far far away: driving HMI requirements towards the comfortable range in Electric Vehicles

[Caterina Calefato, RE:Lab s.r.l.
Reggio Emilia, Italy]
EVs: “How far does it go?”

• EVs are one of the most feasible alternatives to traditional Internal Combustion Engine (ICE), but some concerns for consumers have been identified:

• limited driving range;
• long charging time;
• high purchase price.
EVs: purchasing attitude

- In particular, from consumers’ evaluations it emerges that EVs’ limited driving range might represent the main obstacle to purchase intentions.

- Nevertheless some recent researches state that people were willing to pay a significant amount to reduce emission and save on gas.
EVs: the comfortable range

• The comfortable range refers to the range that users really utilize.

• This can be defined as the highest trip distance between two charging opportunities or the lowest remaining range status, which a user experiences as comfortable.

• This definition attempts to merge absolute value range buffer decision variables with the broadly defined concept of range anxiety in terms of a “fear of becoming stranded”
The RESOLVE project

• The Resolve - Range of Electric SOlutions for L-category Vehicles project is a three years research project co-funded by the European Commission within the H2020 program, started the 1st May 2015.

• The Resolve consortium is made of 14 partners, including PIAGGIO and KTM that are the two largest LV producers in the EU
RESOLVE project aims at:

- enabling the development of a range of cost-effective, energy efficient and comfortable ELVs;
- making advancements to the handling and stability of ELVs together with improving the user interface that will assuage range anxiety and other driver concerns, such as safety and comfort.
# EV customer identification

<table>
<thead>
<tr>
<th>Being younger or middleage</th>
<th>Likely to buy a hybrid gasoline vehicle on their next purchase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having a BA or higher degree</td>
<td>Having a place they could install an EV electrical outlet at home</td>
</tr>
<tr>
<td>Expecting higher gasoline prices in the next 5 years</td>
<td>Likely to buy a small or medium-sized passenger car on next purchase</td>
</tr>
<tr>
<td>Having made a shopping or lifestyle change to help the environment in the last 5 years</td>
<td>Having a tendency to buy new products that come on to the market</td>
</tr>
<tr>
<td>Taking at least one drive per month longer than 100 miles</td>
<td></td>
</tr>
</tbody>
</table>

*Hidrue, M. K., Parsons, G. R., Kempton, W., & Gardner, M. P. (2011)*
RESOLVE project – The survey

Designing the HMI for EVs, the **questions** that designers try to answer to are:

1. What relevant parameters should be displayed in an EV?
2. How should the driver be informed about these important parameters?
RESOLVE project – The survey

- In order to identify the **main HMI requirements for EVs** in general, a survey for domain experts was set up.

- Experts belongs to the **ergonomics, human factors and engineering domains**, since final users may not have an in-depth knowledge of the whole range of in-vehicle HMI functions for the automotive domain generally, and for the EVs domain specifically.
RESOLVE project – The survey

The survey encompassed three different sections:

A. Sample profile
B. Functions for Evs
C. Interaction modalities
RESOLVE project – The survey

- 74 experts
- mainly 25-34 years aged (52.7%)
- male (82.4%)
- with a master degree (68.5%)
7 questions were provided to evaluate which kind of HMI functions should be available on an EV:

<table>
<thead>
<tr>
<th>Function</th>
<th>Disagree</th>
<th>Agree</th>
<th>No opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available range estimation to reduce &quot;range anxiety&quot;</td>
<td>0%</td>
<td>99%</td>
<td>1%</td>
</tr>
<tr>
<td>Energy used (spent/recovered)</td>
<td>10%</td>
<td>89%</td>
<td>1%</td>
</tr>
<tr>
<td>Suggestions on how to improve driving style in terms of energy consumption (e.g. improving regenerative braking)</td>
<td>12%</td>
<td>86%</td>
<td>1%</td>
</tr>
<tr>
<td>Suggestions on how to improve driving style in terms of safe riding</td>
<td>49%</td>
<td>46%</td>
<td>6%</td>
</tr>
<tr>
<td>Availability of charging infrastructures in the surroundings</td>
<td>0%</td>
<td>96%</td>
<td>4%</td>
</tr>
<tr>
<td>In-deep data about vehicle and driving status (e.g. consumption based on routing, diagnostics)</td>
<td>21%</td>
<td>78%</td>
<td>1%</td>
</tr>
<tr>
<td>In-deep data about route (e.g. navigation, traffic)</td>
<td>10%</td>
<td>90%</td>
<td>0%</td>
</tr>
<tr>
<td>Other (please specify in next row)</td>
<td>8%</td>
<td>41%</td>
<td>51%</td>
</tr>
</tbody>
</table>
RESOLVE project – The survey

5 questions were provided to evaluate **which kind of HMI interaction modality is most suitable for an EV**:

<table>
<thead>
<tr>
<th></th>
<th>Disagree</th>
<th>Agree</th>
<th>No opinion</th>
</tr>
</thead>
<tbody>
<tr>
<td>All information to be provided through On-board system</td>
<td>18%</td>
<td>82%</td>
<td>0%</td>
</tr>
<tr>
<td>Additional data to be provided through mobile device (e.g. app for energy consumption trends)</td>
<td>28%</td>
<td>72%</td>
<td>0%</td>
</tr>
<tr>
<td>Driving data to be communicated using visual and auditory channels</td>
<td>25%</td>
<td>72%</td>
<td>3%</td>
</tr>
<tr>
<td>Critical information to be highlighted through haptic/tactile channels (e.g. for safety)</td>
<td>8%</td>
<td>84%</td>
<td>8%</td>
</tr>
<tr>
<td>Interface should be configurable to cope with different users needs (e.g. bigger size fonts for elderly users)</td>
<td>6%</td>
<td>94%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Basing on the evidences of the survey, it is possible to classify the HMI functions into 6 categories and related subcategories:

- **Range**
  - Consumptions
  - Range
  - Energy used

- **Driving style**
  - Suggestions on how to improve driving style in terms of energy consumption
  - Eco-info

- **Recharge**
  - Availability of charging infrastructures in the surroundings
  - Instructions for recharging
  - Status of battery – Battery health status
  - Remaining charging time
RESOLVE project – User needs

- **Route**
  - Navigation
  - Traffic
  - Weather information

- **Vehicle info**
  - Diagnostics
  - Suggestions on how to improve driving style in terms of safe riding
  - Consumption based on routing
  - Data download for offline analysis of actual performance compared to prediction

- **Personal settings**
  - Functions customization
  - Vehicle customization
  - Info displaying customization
What comes into evidence is the importance of delivering to the users the information about the factors that increase the efficiency of EV range use, in order to cope with the accompanying stressfulness of such range utilizations.
HMI has to provide suitable means to cope with range anxiety by:

- adopting fallback options in terms of recharging opportunities
- increasing user awareness of his/her driving style
- incorporating information related to confidence in displayed remaining range estimations
- adding navigational references
RESOLVE project – Final considerations

Future works within RESOLVE project will encompass the exploration of different HMI architectures in order to maximise the ease of use, intuitiveness, and ad-hoc controls that will enable the driver to have better, safer and more effective interactions with the ELV.
Thank you for your attention!