OpenDRIVE
managing the road ahead

4th Meeting
20 March 2007
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Scope of the Meeting

Situation at the beginning of this meeting:
- Participants
  • from various industry sectors
  • from different countries
  • with different background
  • having different interests in the establishment and use of OpenDRIVE

- OpenDRIVE Standard
  • ideas to extend / modify the standard have emerged in the past months

Focus of this meeting:
- Introduction of new community members
- Status and applications of OpenDRIVE
- The future direction of OpenDRIVE
- Presentation and first discussion of ideas to extend / modify of the standard

Technical details will be discussed in the core-team!
Status of OpenDRIVE

DSC 2006, Paris:
- Presentation of OpenDRIVE to an international audience
- 100% positive feedback
- Various follow-up meetings with interested parties

Modifications to the standard since July 11, 2006:
- Oct. 02, 2006: Release of OpenDRIVE 1.1
  • compliant to decisions of 3rd OpenDRIVE meeting
  • released by core-team
  • modification of heading in inertial co-ordinate system

Users:
- "work in progress" at various levels
- new potential and actual users in various countries
- US companies might be interested

Tools:
- Free "OpenDRIVE Manager Lite" for evaluation of OpenDRIVE data available via VIRES website
OpenDRIVE 1.2

- Proposed Modifications and Extensions -

Remark: Please keep in mind when reading the following slides: The information shown therein only represents proposed modifications and extensions to the OpenDRIVE format. These need to be discussed and approved by the core team before becoming part of the standard!
Correction of ambiguous or erratic definitions

- **Material:** exchange *material* for *surface*

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding <em>laneSection</em> record</td>
</tr>
<tr>
<td>material</td>
<td>uint</td>
<td>surface material code [-], depending on application</td>
</tr>
<tr>
<td>friction</td>
<td>double</td>
<td>friction value [-]</td>
</tr>
<tr>
<td>roughness</td>
<td>double</td>
<td>roughness [-] (for sound and motion systems)</td>
</tr>
</tbody>
</table>

- **Object:** exchange single-line definition for range, i.e.

  `<object>...</object>` instead of `<object.../>`
Correction of ambiguous or erratic definitions

- Convention: lane numbers must be unique and in sequence!
Extended Specification (up to 2 neighbors under `link` entry)

**Delimiters:** `<neighbor.../>`

**Parent:** `<link>`

**Maximum Instances:** `2`

**Optional:** `yes`

**Arguments:**

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>side</td>
<td>string</td>
<td>[left</td>
</tr>
<tr>
<td>elementID</td>
<td>uint</td>
<td>ID of the linked road</td>
</tr>
<tr>
<td>direction</td>
<td>string</td>
<td>[same</td>
</tr>
</tbody>
</table>

**Diagram:**
- Blue: has left neighbor (opposite)
- Green: has left neighbor (opposite), right neighbor (same)
- Yellow: has left neighbor (same)
Proposed Features for OpenDRIVE 1.2 - Surface

The file format is currently missing tags for the detailed description of road surfaces (e.g. from measured data)
Key properties of surface data

- derived from real-world measurements
- complex structure
- huge amounts of data
- established data formats which are not compliant with OpenDRIVE XML format (some data sets may be available as binary data only)
- available for entire roads or parts thereof
- surface data may replace the following properties of OpenDRIVE
  - elevation
  - super-elevation
  - crossfall
Inclusion of surface data into OpenDRIVE

- surface data shall be available as a child of the road record since the data is independent of lane descriptions
- surface data shall be referenced only with customized readers performing the actual data import
- various data formats shall be supported

Delimiter:  
Parent:   </surface>  </road>
Maximum Instances:  1
Optional:  yes
Arguments:  none
Example:

```
<surface>
  <CRG sStart="0.0" sEnd="100.0">
    <include file="fancyData.crg"/>
  </CRG>
</surface>
```
Implementation of CRG (Curved Regular Grid) Data

- Include measured road surface data into OpenDRIVE applications
- Highly accurate and detailed description of road surfaces
- Developed by DaimlerChrysler, further information available via TÜV-Süd
  
  www.tuev-sued.de/automotive_de/fachbereiche/fahrwerkstechnik2/produkte_fahrwerk2/3d-track

- Definition of a road profile (in t-direction) at given s-positions
- Definition in OpenDRIVE is designed to be "compatible" with the definition of the original CRG format in terms of:
  • grid spacing
  • parameter interpretation
- CRG data shall be available as a child of the road record since the measured data is independent of lane descriptions
Proposed Features for OpenDRIVE 1.2 – CRG (cont'd)

Motivation

- Ride Comfort Evaluation
- Seat Model
- Chassis Model
- Tire Model
- Road Excitation

Simulation of
- Ride Comfort
- Vehicle Handling
- Durability Load Profiles
Proposed Features for OpenDRIVE 1.2 – CRG (cont'd)

**CRG (curved regular grid) Overview**

**Fundamental Idea**

- Curved Reference Line: \( x(u), y(u) \)
- Regular Grid: \( z(u, v) \)

*Image: DaimlerChrysler AG*
Proposed Features for OpenDRIVE 1.2 – CRG (cont'd)

CRG (curved regular grid) Overview Demo

Figure 6 of `crg_show(crg_read('..//crg/demo_real.crg'))`

- This is the “straightened” curved road.
- Missing measurements are stored as NaNs
Grid types

s: regular, t: regular

s: regular, t: custom
**Proposed Features for OpenDRIVE 1.2 – CRG**

**Specification**

Delimiters:
- `<CRG>...</CRG>`

Parent:
- `<surface>`

Maximum Instances:
- unlimited

Optional:
- yes

Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sStart</td>
<td>double</td>
<td>start position (s-coordinate)</td>
</tr>
<tr>
<td>sEnd</td>
<td>double</td>
<td>end position (s-coordinate)</td>
</tr>
<tr>
<td>tMin</td>
<td>double</td>
<td>minimum t-position of cross section (optional)</td>
</tr>
<tr>
<td>tMax</td>
<td>double</td>
<td>maximum t-position of cross section (optional)</td>
</tr>
<tr>
<td>tOffset</td>
<td>double</td>
<td>offset between cord line and reference line of CRG (optional, default = 0.0)</td>
</tr>
<tr>
<td>zRef</td>
<td>double</td>
<td>reference elevation to which data is relative (optional, default = 0.0)</td>
</tr>
<tr>
<td>zScale</td>
<td>double</td>
<td>z scale factor (optional, default = 1.0)</td>
</tr>
<tr>
<td>orientation</td>
<td>string</td>
<td>[same</td>
</tr>
</tbody>
</table>
Example

```xml
<surface>
    <CRG sStart="0.0" sEnd="100.0">
        <include file="fancyData.crg"/>
    </CRG>
</surface>
```
Proposed Features for OpenDRIVE 1.2 - Road Marks

Road marks shall be signified by "rules" rather than having to interpret width, color, type and weight (which may differ strongly between countries)

Specification

Delimiters: <roadMark/>
Parent: <lane>
Maximum Instances: unlimited
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sOffset</td>
<td>double</td>
<td>start position (s-coordinate) relative to the position of the preceding lane Section record</td>
</tr>
<tr>
<td>type</td>
<td>string</td>
<td>type of the road mark – required</td>
</tr>
<tr>
<td>weight</td>
<td>string</td>
<td>weight of the road mark – optional</td>
</tr>
<tr>
<td>color</td>
<td>string</td>
<td>color of the road mark – optional</td>
</tr>
<tr>
<td>width</td>
<td>double</td>
<td>width of the road mark in [m] – optional</td>
</tr>
<tr>
<td>laneChange</td>
<td>string</td>
<td>[increase</td>
</tr>
</tbody>
</table>
Road marks may be described in more detail with further attributes for specific types

- Types
  - cat-eyes (type, distance, height...)
  - ribs (type, roughness ...)
  - etc.

- For the new types, the tag `<roadMark/>` could be opened into a sub-section in order to contain the additional information
- Information that is relevant e.g. for sound and motion should be included

```xml
<roadMark type="cat-eye" laneChange="none">
  <cat-eye type="single" distance="0.5" height="0.02"/>
</roadMark>
```
Replacement of (unique) numeric IDs with names in order to make the files more user-readable.

- **Affected tags and arguments**
  - Object: type, id
  - Signal: id
  - Lanes: type, level
  - Material: surface
  - Tunnel: id
  - Bridge: id
  - SignalReference: signal id
  - Controller: id
  - Control: signal id

- **Unique numeric IDs will be continued to be used for**
  - Road
  - Junction
  - Lane
  - all references to junctions, roads and lanes

Remark: The discussion during the meeting was in favour of using names instead of numeric IDs for these features.
Objects shall be provided with a "repeat" option

Specification

<table>
<thead>
<tr>
<th>Delimiters:</th>
<th>&lt;repeat.../&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent:</td>
<td>&lt;object&gt;</td>
</tr>
<tr>
<td>Maximum Instances:</td>
<td>unlimited</td>
</tr>
<tr>
<td>Optional:</td>
<td>yes</td>
</tr>
<tr>
<td>Arguments:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td>double</td>
<td>start position (s-coordinate), overrides argument in &lt;object&gt; record</td>
</tr>
<tr>
<td>length</td>
<td>double</td>
<td>length of range in [m]</td>
</tr>
<tr>
<td>distance</td>
<td>double</td>
<td>distance in [m] between two instances of the object</td>
</tr>
</tbody>
</table>

Example

```xml
<object name="post"...>
  <repeat sStart="123.0" length="1200.0" distance="50.0" />
</object>
```
Enhanced representation of objects

- Introduce an `<objectReference.../>` in order to refer to a single object from multiple roads.

- Exchange object definitions below `<roadHeader>` level with a section defining objects independently of roads and with a new `<objectReference>` tag for the instantiation of objects along roads.
Introduce **sets** of definitions for various features

- This will allow the application to switch between various pre-defined configurations of the road network.

- Possible applications:
  - test different road mark sets of a given road
  - test different road materials of a given lane
  - test sets of signaling
  - etc.

- Parameters/Hierarchy:
  - unique name for identification
  - instances below "set" level
Proposed Features for OpenDRIVE 1.2 – Sets (cont’d)

Specification

Delimiters: <set> </set>
Parent: various
Maximum Instances: 1
Optional: yes
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>string</td>
<td>name of the set</td>
</tr>
</tbody>
</table>

Delimiters: <instance> </instance> <set>
Parent: <set>
Maximum Instances: unlimited
Optional: no
Arguments:

<table>
<thead>
<tr>
<th>name</th>
<th>type</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>string</td>
<td>name of the instance</td>
</tr>
</tbody>
</table>
Example

Define the lanes of a road for regular configuration and for a road works area

```xml
<road ...>
  <set name="roadWorks">
    <instance name="regular">
      <lanes>
        :
      </lanes>
    </instance>
    <instance name="construction">
      <lanes>
        :
      </lanes>
    </instance>
  </set>
</road>
```