Enhanced reality, adaptive training and virtual instruction
– New approaches to simulator-based driver training concepts

Heidi Grattenthaler, Alexandra Neukum & Hans-Peter Krüger
IZVW, Universität Würzburg
3.TTD Dresden, 23.-24.11.2011

who we are and what we do

- driver assistance and automation
- driver state and fitness to drive
  - workload, fatigue
  - older drivers, diseases (e.g. Parkinson’s disease)
  - psychotropic substances
- traffic interaction: C2C/C2I
- driver education and training
- driving simulation
- road design

Grattenthaler, Neukum & Krüger, 3.TTD, Dresden, 24.11.2011
**EU-Project TRAIN-ALL**

**Task:** Development of new training approaches for simulator-based driver training for different driver groups with a deliberate balance between didactics and technology

**Duration:** 11/2006-12/2009

**Partner:**

- Grattenthaler, Neukum & Krüger, 3.TTD, Dresden, 24.11.2011

**TRAIN-ALL enabling technologies**

- Enhanced Reality
- Adaptive Training
- Virtual Instruction
Enhanced Reality

Based on the concept of Augmented Reality (AR)

AR is a process of enhancing the real world with computer-generated information to improve the interaction of the user and the real world (Kalawsky et al., 2000), i.e. reality is augmented with additional data given through a display device.

Application fields: medical and military training; automotive, aviation and astronautics industries (for examples see Azuma, 1997; Regenbrecht, Baratoff & Wike, 2005; Sielhorst et al., 2004)

- Industrial applications: aim at supporting a user while performing a task

- Training applications: aim to support learning through online feedback, should include fading of support (Young, Stedmon & Cook, 1999)

Enhanced Reality - Developments

- Application to simulator-based driver training: enhancement of safety-relevant driving parameters within the scenery which typically are not present or even cannot be seen in reality

  - Training challenge: selection and elaboration of the visualisation design for elements
  - Technical challenge: finding technical solutions to display the elements and enable their interaction with drivers actions

<table>
<thead>
<tr>
<th>selected key driving parameters</th>
<th>time-headway</th>
<th>target speed</th>
<th>time-to-collision</th>
</tr>
</thead>
<tbody>
<tr>
<td>task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>car following on rural road</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>exiting highway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>approaching other vehicles on rural roads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>target group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>novice car drivers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>novice car drivers, emergency response drivers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ER implementation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grattenthaler, Neukum & Krüger, 3.TTD, Dresden, 24.11.2011
Enhanced Reality – Evaluation

driving experience (DE): no driving experience (n=12) / ≤ 6 month driving experience (n=11)
Enhanced Reality (ER): training with ER elements – verbal instruction
procedure: practice drive – test drive

<table>
<thead>
<tr>
<th>Practice</th>
<th>Instruction</th>
<th>ER – car following graphical element enhances safe and unsafe time-headways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Instruction</td>
<td>no ER – car following application of &quot;Two-Second Rule&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Please apply the &quot;Two-Second Rule&quot; and follow the vehicle ahead with a safe distance. Try to drive constantly with a safe headway.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Both groups were instructed to constantly keep a safe headway of around 2s to the preceding vehicle.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>performance parameter: practice and test: error time [%] with a TH &lt; 1.8s</td>
</tr>
</tbody>
</table>

Enhanced Reality – Evaluation results

Example: Performance and acceptance results for car following

practice rides: better performance if TH is visualized hidden learning effect!
but: only for car following element
+/− partly enhances performance
- distraction

→ further design improvement necessary, fading not addressed
TRAIN-ALL enabling technologies

- Enhanced Reality
- Adaptive Training
- Virtual Instruction

Adaptive Training

- currently, simulator-based training sessions typically provide all trainees with an identical sequence of driving tasks, independent from their actual performance

- adaptive training: individualising the training schedule

- improvement of learning progress: low-performance trainees will get as much practice as needed

- improvement of training time efficiency: good-performance trainees receive less training time

- application fields: memory training, learning foreign languages, playing instruments and learning perceptual–motor control tasks (for examples see e.g. Patrick, 1992; Williges, Roscoe & Williges, 2001; Metzler–Baddeley & Baddeley, 2009)
Adaptive Training

application to simulator-based driver training:

1. training materials: driving scenarios targeting different driving tasks – database of scenario variants per task

2. performance measurement: driver behaviour data

3. adaptive logic: performance evaluation
   -> based on this evaluation training scenarios are linked during run-time

- training challenge: specification of training contents and according driving scenario variants (database) together with performance criteria
- technical challenge: development of a new architecture that allows for scenario variants to be connected to each other during runtime

Adaptive Training – Evaluation

subjects: 17 drivers with no experience in emergency response

training schedule: adaptive (n=8) / fixed (n=9)

1. training

   ADAPTIVE SCHEDULE

   performance assessment: number of errors (error classification)

   adaptive schedule: adaptive course
   -> simulation connected dynamically all the task variants during run-time

   fixed schedule: all variants
   -> predefined scenario sequence

2. test

Grattenthaler, Neukum & Krüger, 3.TTD, Dresden, 24.11.2011
Adaptive Training – Evaluation results

- comparably high number of errors in 1st round
- errors decrease from 1st round to test

+/- partly enhances performance
- high technical effort

- consider an extended rationale for task selection
- exploit possibilities of online assessment

TRAIN-ALL enabling technologies

- Enhanced Reality
- Adaptive Training
- Virtual Instruction
Virtual Instruction

as far as reasonable and technically feasible a Virtual Instructor (VI) may either assist the human instructor or take over some of his/her tasks:

- delivery of instruction and feedback,
- performance assessment

100% virtual 100% human

-> VI concept: free the instructor from 'routine tasks' and give support for performance assessment and feedback

=> combination of CBT and simulation to allow different interaction levels for trainee and trainer

1. Integration of CBT allows to prepare trainee with basic instructions before every new task

- frees the trainer from giving the same basic instructions repeatedly
- tight linking of theory and practice (per task: briefing CBT – ride)

basic instructions
(briefing): CBT

Briefing:

Im Folgenden wirst Du auf einer Landstraße hinter verschiedenen anderen Fahrzeugen her fahren.

Dein Lernziel für das kommende Scenario: Fahre mit einem sicheren Abstand hinter den Fahrzeugen her, in dem du die 2-Sekunden oder die halbe-Tacho-Regel anwendest.
Virtual Instruction

2. More powerful computer performance meanwhile allows to assess and evaluate the trainee’s driving performance more and more during run-time -> FEEDBACK
   - simulation represents situations and driving behaviours in variables of space and time
     - precise measurements
   - feedback: speech, video and text (CBT); during and after training

Feedback during the ride:
voice message

Session debriefing:
   - CBT + video replay
   - general and learning goal related errors
   - conditioned feedback for trainer and trainee (different amount of detail)

1. Integration of CBT allows to prepare trainee with basic instructions before every new task (‘scenario briefing’)
   -> frees the trainer from routine tasks

2. More powerful computer performance allows to assess and evaluate the trainee’s driving performance more and more during run-time -> FEEDBACK
   - speech, video and text; during and after training
   - CBT and replay: trainer receives a detailed performance protocol, trainee a conditioned protocol

3. VI functions can be based on assessing the trainee’s driving performance online and especially with regard to time- and distance-based performance criteria
   - advantage: performance assessment with precise measurements (on- and offline)
   - requirement: definition of performance criteria
     - but:
       - not all behaviour is yet measurable in the simulation (e.g. not paying attention to certain cues)
       - performance standards are missing (e.g. how much driving with a safe distance in car following is needed to be a good driver/a good beginner driver…?)
Virtual Instruction – Evaluation results

• acceptance of VI functions (feedback trigger, replay marker, switching CBT <-> simulation)
• subjects: employees of IZVW/WIVW who regularly evaluate the driving performance of other people for training and scientific research purposes (n=4)
• procedure: demonstration of VI functions

acceptance:

*The simulator cannot automatically detect all possible driving errors.*
*Audio feedback and CBT do probably not cover all the feedback a trainee might need.*

-> successful technical evaluation
-> positive acceptance ratings

Conclusion

modern computers and graphics offer a rich field of new applications
-> their impact on learning efficiency seems plausible, but is not finally proved:

• Enhanced Reality:
  • results point out a clear need for further improvement of the design of such elements
  • feedback issues (fading) need to be addressed
• Adaptive Training:
  • consider an extended rationale for task selection
  • exploit possibilities of online assessment
• Virtual Instruction: supporting trainers
  • CBT and simulation can be combined to support the human instructor
  • broader knowledge on performance criteria/standards for training tasks is needed
  • trainees: acceptance and influence on learning efficiency have yet to be demonstrated
Thank you!

Interdisziplinäres Zentrum für Verkehrswissenschaften an der Universität Würzburg (IZVW)

grattenthaler@psychologie.uni-wuerzburg.de
neukum@psychologie.uni-wuerzburg.de
krueger@psychologie.uni-wuerzburg.de