Future Applications of DHM in Ergonomic Design

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Abstract. Until now DHMs are especially used to design the dimensions of products and production assembly according to anthropometric demands. Recently DHMs are additionally equipped with strengths simulation so that also the dimensioning of reaction forces is possible. First steps are done to describe and evaluate the contact between human body and environment. Some examples will be shown. However in this area further important steps are necessary. Especially the self paced calculation of posture depending on this contact is to be realized. Some proposals exist for the contact of seat and body. Also first basic research is done in order to simulate motion behavior. Especially the detection of "leading body elements" as basic idea for this simulation can be seen as an initial step to generate modeling of cognitive human properties. However, in order to realize it the simulation of the properties of sense organs is necessary. Certain properties of the eyes can be simulated rather simple. Meanwhile some experience exits to understand the glance behavior depending on specific tasks (e.g. car driving). That can serve as basic for input to cognitive models. The output of these can be the track in space of the leading body element. On the other hand sensor organs properties in the field of hearing and climate are possible. In both cases the more difficult problem is to simulate the properties of the environment. General application field of these future development is the computer aided ergonomic design of workplaces in production lines and of products especially vehicles already in the definition and development phase. In this connection is to be considered that in future especially the design of information flow in these areas becomes dominant. An example is the growing development of assistance systems in cars. The application of DHMs will allow achieving the connection between information design and the necessary geometric design of the equipment.

1 Introduction

Since the middle of the sixties digital human models have been developed in order to simplify the anthropometric lay-out of technical equipments. During this development we can observe two important lines:

- In the one line especially mechanical and physical properties are represented by computer programs. The original aim was to make predictions of the weightless human body in the space. Later on, this kind of simulation was used to calculate the behavior of dummies during a crash experiment in the car development. By this approach a part of the very expensive crash experiments should be substituted by

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the cheaper computer simulation. An example of industrial applied DHMs of this kind is the MADYDYMO, developed by TNO in the Netherlands.

- The other line is the development of anthropometric models that should represent the geometric and strength like human proportions. They are used to design the geometric layout of working places and especially narrow cabins as they are given in every kind of vehicle. The today most important models of this kind are JACK, developed in the USA, SAFEWORK, developed in Canada and nowadays incorporated in the CAD-tool CATIA V, and RAMSIS, a software tool developed by the enterprise Human Solutions and the Technical University Munich encouraged by the community of the German automotive industry. The last one is meanwhile world wide well established as tool for the packaging lay-out in the automotive industry. Further the new development SANTOS is to be mentioned. It is the project "Virtual Soldier" that is initiated and supported partly by the US Army TACOM project 'Digital Humans and Virtual Reality for Future Combat Systems (FCS)' and by the Caterpillar Inc. project 'Digital Human Modelling for Safety and Serviceability.' According to his authors (Abdel-Malek et.al, 2006) it promises to be the next generation of virtual humans.

The following paper will deal especially with the development of RAMSIS, as it generally represents the development of such software dummies. A further reason is that the author of this article knows and pushes this development as one of the researchers for this project. Of course, the trends demonstrated by this example can also be observed in connection with the other models, however in different expression.

2 Examples of Application

In order to understand the necessary future development some typical examples of today application of such DHMs are presented firstly in the following. In connection with working places in the production very often questions of reachability arise. The very good geometric representation of DHMs allows treating such problems with certain accuracy (See Figure 1) especially with view on the different anthropometries of the workers. However, the effort to create such pictures is rather height and until now no enough accurate posture and motion models exist to create a "natural" posture under all conditions. The good representation of the anthropometric variety allows designing even safety critical cabins. For example a special safety handle for roller coasters was designed that can be adapted to all appearance of body shape from small children up to fat big male people (see Figure 2). However, until now the most realistic representation of human behavior is given for the driver's posture in a passenger car. For this purpose e.g. in the case of RAMSIS extended research was carried out.

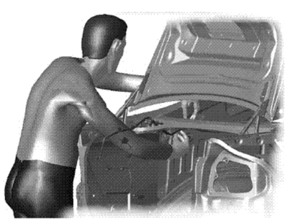

Fig. 1. Investigation of reachability with the help of DHMs in connection with questions of production

As reported by Bubb et al. (2006) instead of the usual inverse kinematic the most probable posture is

calculated by an optimalization algorithm that is based on experiments of the distribution of the angles in all joints of the human body during car using. By a regression appropriation even the discomfort caused by the necessary external conditions – the so-called restrictions - can be predicted. The correspondence between the calculated posture and real posture was evaluated by many studies (e.g. Kolling, 1997). This system can be used to adapt the so-called packaging of cars to
the variety of human's body size und to find out the optimal adjust equipment that is necessary to realize this aim (see Mergl et al., 2006).

During all applications the contact between the DHM and the environment is a big problem. Especially the pre-calculation of the contact in seats is of main interest. Different approaches to solve this problem are reported. In many cases the properties of the seat are described by the H-Point, measured by the H-point machine after SAE-J 826. In the case of RAMSIS actual seat experiments with subjects of different size are carried out in order to find out the offset between the H-Point that describes the properties of the seat and the hip-joint axis of the DHM RAMSIS. Ippili et al. (2002) describe an algorithm based on a simplified model, by which posture and force distribution can be calculated depending on the foam characteristics of the seat. A similar, however 3-D approach is reported by Schmale et al. (2002) that even provide a calculation of the

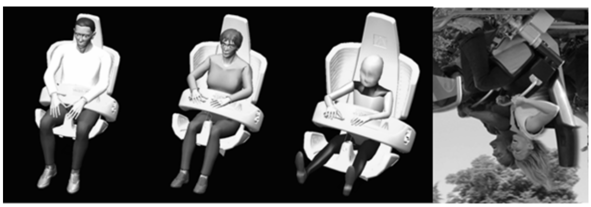

Fig. 2. Design of a rollercoaster seat by RAMSIS and the realization "Sky Wheel" by Maurer & Söhne

pressure distribution in the contact plane between the DHM COSYMAN and a parameterized seat. Mergl (2006) presents a FEM model of the deformability of the upper leg. It shows good agreement with observed pressure distributions of subjects. In connections with a posture prediction model so the pressure distribution in a virtual seat can be calculated. By Mergl et al. (2005) a discomfort model was developed by which this pressure distribution can be evaluated according to the expected discomfort. By all these measures the discomfort model based only on joint angels is enlarged and improved.

However, is this enough? All the described models cannot predict an arbitrary posture under every thinkable condition. It is only valid for sitting postures, especially driver sitting postures. As in future not only forces but also motion and recognition by the sense organs become important in connection with CAD applications, the modeling of human properties and behavior is to be started by deliberations that consider physiological and psychological knowledge from the beginning.

3 New DHM Developments

3.1 Primary Deliberations for New DHM Developments

A general human model that is very established in the area of ergonomic application divides between

- information reception, realized by the sense organs,
- information processing, realized by the central nerve system, especially the brain, and
- information transformation, i.e. motion by innervations of muscles.

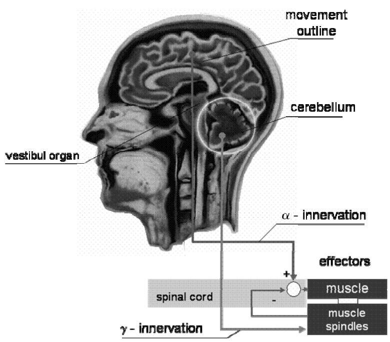

Fig. 3. The physiologic background of information reception, information processing, and motion innervations

Figure 3 shows the physiologic background of this categorization. By the receptor system external stimuli are transferred to nervous stimuli. The pattern of these is analysed by the complex and hyper-complex cells. The combined information of all sense organs stimulates memory contents. That means we combine information of the various sense organs to a singular recognition of the external world without direct conscious recognizing from what sense organ the information comes. The action that has been apparently successful in connection with this stimulus configuration is also a part of these. The action is realized by connecting the desired action to the effectors, i.e. the musculature. From the motor-sensory cortex this information runs via the so-called α-innervations to the spinal cord and excite there the so-called α-motor-neurons. These are directly connected to the corresponding muscles, the effectors. By the muscle spindles the expansion of the muscle is "measured" and fed back to the α-motor-neurons. By this closed loop system in the spinal cord a posture desired by the brain and signalled by the α-innervations is realized. In a special case this is also known as "knee-jerk". However, there exists a second way to initiate a motion: by the so-called γ-innervations the length of the muscle spindles can be influenced and so a motion can be produced. By these γ-innervations on the one side an adaptation to fine regulation is possible and on the other side the body equilibrium in the field of gravity is guaranteed. The reason is: γ-innervations are especially connected with the cerebellum and this has essential connections to the vestibule organ.

The task of human modelling is to rebuild these natural given conditions. In this connection two questions are to be answered in the first step and modelled in the second step:

- On the psychological level: "what is in a given situation the desired movement?"
- On the physiological level: "By what interaction of muscles is the motion realised?"

In the following first the physiological level is to be considered because it is the fundament of the psychological level that describes the intentional "willing" of the model.

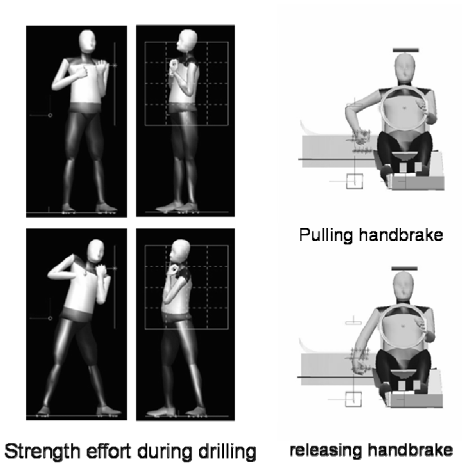

Fig. 4. Examples for the poster calculation by the FOCOPP-Model

By Seitz and Recluta (2005) the Force-Controlled Posture Prediction-Model FOCOPP was developed. Integral part of this approach is an accurate physical description of test subjects. The physical characterization includes anthropometry, masses of body parts, centre of gravity, angle dependent resistant torques and maximum torques for each joint of the body. This approach assumes that humans want to minimize the joint strain when taking a desired posture. This approach has been formulated within a MATHEMATICA and RAMSIS simulation and exemplary evaluated for different tasks (see Figure 4). By the experimental experience this model was confirmed. Furthermore, the individual load and discomfort based on the found correlation between load and discomfort assessment can be predicted (Zacher and Bubb, 2005). Of course, the gravity field is a further part of this calculation.

The generated approach for optimization considers the human biomechanical characteristics by connecting the effective moments inside a joint to relative strain. The posture optimization consists in the change of the degrees of freedom in different joints in that way that the strain is minimized. The modelled parameters of influence are maximal forces and passive resistance moments effected by the muscular system. In order to describe the passive resistance joint moments a measuring device was developed to analyze postures in a quasi-weightless state (Marach, 1999). Maximal forces were measured by Schaefer et al. (2000) and used for the model. The corresponding posture angles were measured by the contact-less stereo-photogram-metrical posture analyzing system PCMAN (Seitz, 1998).

3.3 Psychological Level

Arlt (1999) developed a new model that can acquire dynamic constraints for any human motion by external parameters. Than by applying the FOCOPP-Model the posture of the remaining body elements can be calculated. In order to generate dynamic constraints a theory of human motion from the field of neurophysiology was combined with psychological discoveries and adjusted to the problem of the use within the digital human model. The result is: for every movement exists a „leading body element (e.g. hand, finger, foot, buttocks etc.). The path of it defines additional “dynamic restrictions”. For this three control components exist:

- Transportations component: it defines the course in space and time between start-point and target-point. As could be shown in different experiments the moving path always is within a plane defined by the start and target point. The run of the path is like a parable and defined by the detaching and approaching vector and depends on the kind of grasping.
- Aligning component: the leading body element is to be aligned to the shape of start and target object. The detaching and approaching vector depends on the kind of grasping given by the form of the corresponding objects.
- Optical component: In order to adapt the motion to the external conditions information about spatial destination, position, and form of the aimed object must be obtained.

In order to model motion it is to be distinguished between:

1. “Conducted motions”: the corresponding leading body part (for example foot) is quasi fixed to an object, whose motion is controlled through technical parameters (for example pedal).
2. “Simple perfect motions”: the motions trajectories can be fully and autonomously found by the person. They are characterised by the detaching from an object and by the reaching of a target-object (for example from the steering wheel to the gear lever).
3. “Modified motions” are “perfect motions“, which are disturbed by the avoidance of an obstacle.
4. “Complex motions” are distinguished through the correct time-co-ordination of several simple perfect and modified motions (for example the process of ingress in a motor car).

Furthermore Arlt found that in the case of obstacles (“modified motion”) the human operator keeps a safety distance to the obstacle. This safety distance depends on the body element (it is very low for hand and foot and biggest for the head) and it depends on the moving speed. With increasing speed the distance becomes lower.

4 Modeling

4.1 Modeling and Evaluation of Motion

Cherednichenko et al. (2006) enlarged the model of Arlt by investigation of “complex motions” in the context of entering a car. By this he made an important step to a general modelling of motion. By experimental observation and by the attempt to model this experience he defined three main levels:

- Planning level: on this level the target of the motion is defined.
- Guiding level: on this level the motion more in detail is planned considering all conditions of environment and obstacles. An essential part of this level is the backward planning.

- Stabilization level: on this level the motion becomes reality. All autonomous reactions of the body, by which equilibrium and reduced effort is realized, becomes now important.

It is important to mention that these three levels seem to be of general importance for human activities. Also in the case of driving a motor car we know these three levels (see 4.2). Cherednichenko especially modelled the guidance level. An essential part of it is the definition of the leading body elements and the coordination of different body elements. As already found by Arlt also Cherednichenko could define experimentally the leading body element by the fact that the motion of it is always exactly in a plane. It is of interest that always only one leading body element exists. That seams to be attributed to the restriction of the active brain's capacity. However, in the case of a complex motion several leading body element are activated according to a motion plan.

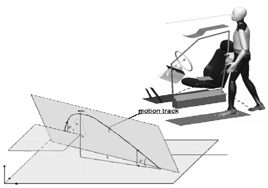

Fig. 5. Prediction of the motion of the leading body element in the case of entering a car

In the case of the ingress manoeuvre the leading body elements are

1. the right foot (in the case of steering wheel on the left side!),
2. the pelvis,
3. adjustment of the right foot,
4. adjustment of the left foot,
5. hands to the steering wheel.

Depending on conditions in the environment (e.g. position of the door sill, position of the A- and B-column etc.) he found rules, by which this plane is defined. Now, depending on the obstacles in the environment the exact motion track can be calculated (see Figure 5). On the stabilization level by use of the FOCOPP-Model the posture and motion of the rest of the body elements are calculated. It could be shown that by this procedure a good agreement between observed motion and calculated motion is achieved.

The next step is to evaluate such motion according to the expected discomfort. In combination with other discomfort factors, like body posture or seating pressure (see above), the overall discomfort may be predicted at any time instantly. This is an essential step introducing psychophysical relations to get on man's emotional world for further technical operations. The idea is to "explain" human behavior by some kind of "hedonic optimization", not in a physical but in a pure emotional world (Schaefer and Zacher, 2006). In the end, this approach may help to identify those postures and movements that are reducing perceived discomfort to a minimum, possibly ending up in some kind of autonomously moving manikins.

In order to draw a conclusion from the static discomfort model to a dynamic model it is important to measure movements and to analyze them in connection with the evaluation of discomfort. Therefore experiments were conducted with the aim to approve an approach for the dynamic modelling of discomfort. The subjects had to lift different weights on a rack positioned in various heights. After the movement the subjects were asked about their global discomfort feeling and the discomfort in defined body parts and joints (e.g. shoulder, elbow). The results assert that the maximum discomfort in one body part or joint is the same as the global discomfort. A movement analysis was conducted with PCMAN, so that the time histories of all joints were known.

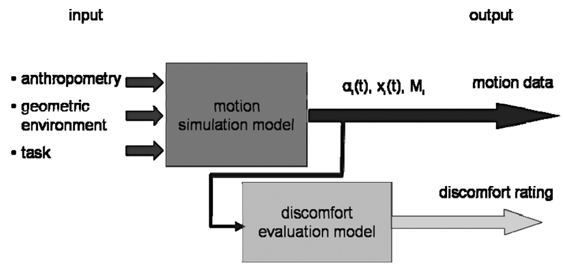

Fig. 6. General simulation model of motion and evaluation of motion

Using the multi body system simulation software ALASKA with the human model DYNAMICUS the time dependant joint torques were calculated. If it is possible to adapt the static discomfort model to the dynamic requirements concerning the maximum force, it will be possible to calculate the development of the discomfort during a movement in every joint (dynamic model). Knowing the connection between the local and global discomfort one will also be able to state a value for the global discomfort for a complete movement or a sequence of movement. Thus, improved conditions for the analysis and assessment of discomfort in the area of ergonomics and design can be created. The background idea for this procedure is presented in more detail by Fritzsche (2007) in this proceeding. Figure 6 shows the idea of this evaluation approach in an overview.

4.2 Modeling of Information Perception

The next important step to come to a complete human model is the modeling of the sense organs. Of course with view on application not the physiological properties of these sense organs are to be modeled but only their properties under the view of information transformation. The most properties of the sense organs are for a modeling rather well known enough. The much bigger problem is the modeling of the environment. For example for a pre-calculation of the acoustic field not primary the properties of ears are important but the exact pre-calculation of the sound field. The same calls for the thermal environment and for the influence of vibration (beside of the reaction of the human body on it, which is modeled rather well, e.g. by Verver, 2002 and Fritzsche, 2005). Under the view of human modeling especially the modeling of glance behavior and visibility is of importance. Although it is no problem to simulate the view from the two dummy eyes in the virtual world and thereby to evaluate the visibility of the environment e.g. depending on different anthropometries, it is a big problem to visualize the effect of ametropia and presbyopia. A further difficulty is to pre-calculate the effect of reflection and glare. In this case again a good modeling of the surrounding surfaces is necessary. By software dummies it is possible to calculate the sight conditions and hidden surfaces with respect to the variation of anthropometry. In this connection the challenge is to present the result of such calculations in understandable form. A main problem however is to calculate the glance behavior. In experiment together with DaimlerChrysler the viewing areas during driving were investigated. For this purpose a special experimental car was developed, the so-called glass dome car, by which under total unrestricted conditions the glance behavior in normal traffic situations could be investigated (see Figure 7). Beside the trivial result that, of course, the main glance direction is oriented in the area ahead the car, specific areas during curve driving could be detected. A further result was that the driver shows a strong inclination to keep the glance through the windscreen. As far as possible he avoids the glance through the side windows. That has impact to the design of position and form of the A-columns.

Fig. 7. The "glass-dome-car" of DC and a comparison between glance behavior and hidden viewing areas

The course of the road, vehicles and other traffic participants, as well as environmental conditions and weather determine the driving task. To accomplish this task the driver has to fulfil three hierarchically ordered tasks (Bernotat, 1970, Allen et. al., 1971 and many others): By the navigation task in the external loop he lays down generally, how the existing road network should be connected in order to reach the desired destination. This is the input for the task in the next lower loop, the guidance task. On this level the driver determines the desired course that decide in the immediate surrounding field of ca. 200 m how the vehicle should move in location and time. On the lowest level, the stabilization task, the driver detect the necessity information from the visual environment und transforms it in adequate handling of the control elements so that the actual lateral and longitudinal position of the car corresponds with a certain tolerance to the desired position, the so-called "result". It should be mentioned that this process corresponds totally to the three levels of body motion initiating, described in 4.1. Altogether, the driving task can be reduced to the demand: every contact with standing or moving objects in the traffic field has to be avoided.

However, the description above does not mention all tasks that are to be accomplished during driving. According to a proposal of Geiser (1985) the total driving task can be divided in the following subtasks. The *primary driving task* is the task that is described already above. It is the actual driving process that aims to keep the car on the road.

Beside of that the driver has to accomplish additional tasks. Those arise in the framework of the primary driving task depending on traffic and environmental conditions as well as those that are necessary in order to inform other traffic participants about intended manoeuvres. For example the operation of the flasher, the wiper, the lamp switch, the horn, and in the case of a hand switched car the use of gear lever and clutch pedal belong to these tasks. Also assistance systems like Tempomat or ACC-system have to be operated on this level. All these control elements have to be used always depending directly or indirectly on the driving task. Therefore they are assigned as *secondary tasks*. In a further breakdown they can be divided in *reactive tasks* and *active tasks*. The reactions on a change of external conditions like to dip the headlight in the case of oncoming traffic or to switch the wipers in the case of rainfall are reactive tasks. Principally they can be automated. By active tasks the driver shows his intention (e.g. by using the horn).

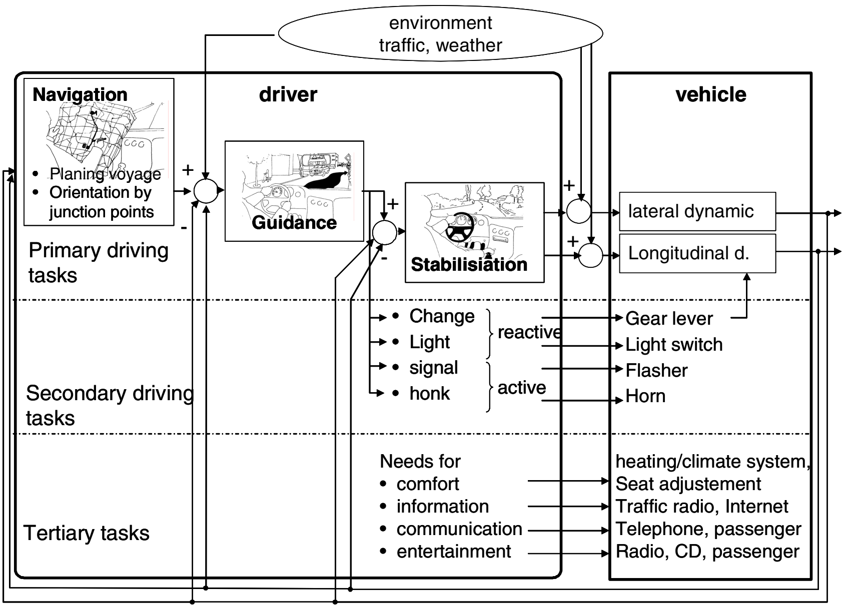

Fig. 8. Closed Loop Driver - Car

Tasks that have nothing to do with the driving tasks but aim to improve the needs of comfort, entertainment, and information are called *tertiary tasks*. The use of the heating/climate system, the radio, the telephone, and in further future additional equipments like internet and communication with office and home technologies belong to these tasks. Also in this case it can be divided between active and reactive tasks. Figure 8 shows a structure image of the driver's tasks.

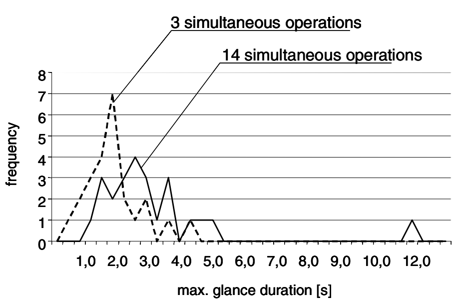

Fig. 9. Glance attention in connection with tertiary tasks

Rassl (2005) investigated the influence of tertiary task and different layout of such tasks on the glance behaviour. Beside others his subjects had to choose one of 3, 5, 8, and 14 options by a central control element (similar to the BMW i-drive controller) during driving. It is of interest that the selection needs in average about 1.2 seconds and there is no significant difference between these deviation times depending on the number of presented options. However, when we look at the maximum duration of distracted glances the case of 14 options is significantly different from the others. The maximum distraction time in this case is on average 2.2 seconds. As Figure 9 shows, in this case one time even a distraction time of 12 seconds was observed. That is not a singular event! In the research of Rassl in another part of the experiment even 16 seconds distraction was observed and in further not jet published experiments with the operation of the climate system we also found distraction times of 12 seconds. By other experiments Treugut (2007) could show that the glance duration to a tertiary task depends on the position of the indicator or the screen in the environment of the driver. When this position is closer to the view direction on the road, the driver keeps the glance longer on the display because he has the impression to keep the road in view in the periphery. It is an actual question, where is the optimum between a certain peripheral perception, however inexact observing of the main task - it is the driving task - and the more urgent impulse to turn the glance back to the main task after a duration of normally 2 seconds.

The experience of such experiments can be modelled and in not too far future it will be a further simulation part of DHMs.

4.3 Modeling of Cognitive Behavior

Whereas presently - caused by the technical development – the load of information processing by secondary and especially tertiary tasks and the design of the equipment for it is object of actual research, the investigation and design of the primary task is the core of the design that promise a reduction of accident frequency and an improved handling of the car. It makes necessary to model the core of cognitive behaviour. We have to answer the question: how does the human information processor work in connections with driving tasks? Answering this question also other interaction between the human operator and the technical equipment can be predict.

In general glance behaviour is one key to consider how information gets into the brain. As by the fovea centralis of the eyes only a small angle sphere of about 2° - 3° can be resolved sharply, the eye must scan sequentially the scene, in order to receive the situation. Therefore, the strategy of this scan behaviour depends on the attractiveness of the objects in the environment. So, the glance behaviour can be seen as a peer scope into the internal information processing behaviour. However, any changing stimulus that reaches the peripheral sphere of the eyes effects immediately to direct the glance at the moving object.

When we observe glance behaviour by an eye tracking system during driving we can distinguish between “scanning” and “processing” (Cohen, 1976) Scanning glances have a rather short duration of averagely 400 ms. By scanning especially the edges of the road, other traffic participants and traffic signs are received. Processing means that special - so-called - areas of interest (AO’s) are fixated. That can be the instruments, the mirror, and the display of the car but also objects in the environment, which are not relevant for the traffic. The processing glances need on average twice of the time of scanning glances (see Figure 10).

By scanning internal models are stimulated that are stored as a general concept in form of a structural engram in the long term memory. By this stimulation the

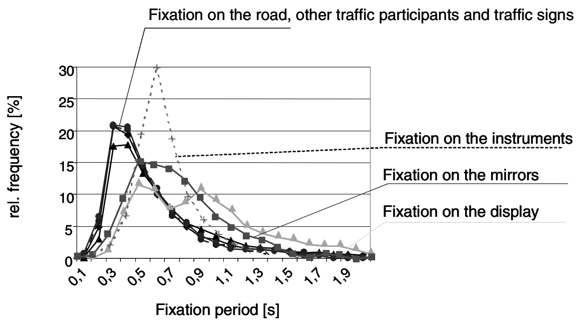

Fig. 10. Experimental results of eye tracing researches (Schweigert, 2003)

corresponding internal model is "waked up" and becomes in this way a part of the working memory. This process shall be understood more exactly by the example of driving on a road bended to the left. The information received by the scanning stimulates a general internal model of a concept of left bended road. By adapting this concept to the real stimuli in the working memory the driver recognizes the real width and the real curve of this road. Further scanning stimuli give him information about traffic participants on this road. The scanned information of these objects stimulates also internal models of their behaviour. By this way only a short glance is enough to recognize the speed and the course of an oncoming car or the expected behaviour of a foot passenger. As the glance can only scan the scene in a sequence, it is possible that relevant objects are not observed. The combination of all this information gives the driver a feeling of the presence of the situation. He thinks only this internal image as reality.

Felt present has duration of 2 to 3 seconds (Pöppel, 2000). This has big importance for the glance behaviour. All experiments with glance behaviour in car driving show that normally only in a distance of 1 to 1.5 seconds ahead information is scanned (distance = speed x preview time; Donges,1978; Yuhara et al., 1999; Guan et al., 2000, Schweigert, 2003). And there are a lot of experimental results that show that the driver accepts normally to take the view from the road for up to two seconds (e.g. Zwahlen et al. 1988, Gengenbach, 1997, Schweigert, 2003).

This felt present encourages the driver to keep not always the glance on the road. Schweigert (2003) carried out glance research in enlarged experiments. He found out that the glance was directed also to non traffic relevant objects in 89% of all observed traffic situations under normal non stressing conditions. When the traffic situation becomes more difficult, the driver reduce first the glance on these non traffic relevant objects, than to specific areas of interest, than he reduce the attention to traffic signs, tachometer and mirrors. When the situation becomes very complex it can be observed that the driver in 41% of all cases counts on other traffic participant's behaviour according to the rules. When the situation becomes still more complex in 7 % of the situations the driver omits even the glance to primary necessary information.

All these experiments allow step by step a modeling of human behavior. The control of glance behavior by internal models enables modeling more deeply the information receiving process. However, the same models are connected with the information realization by innervations of muscles. This process can be modeled by the idea of the leading body element. Some ideas from the modeling of human behavior with methods of control theory, as it was done in the research field round McRuer in the 60th and 70th, can help to predict the dynamic properties more exactly. So, knowing the technical design of given equipment represented in CAD, it will be possible to judge what information the operator can take in view and what is probably neglected. In connection with existing methods in this area the human error probability may be estimated. All taken together a prediction of the usability already on the basis of CAD becomes attainable. Figure 11 shows a survey on such a future model for that actually research is done.

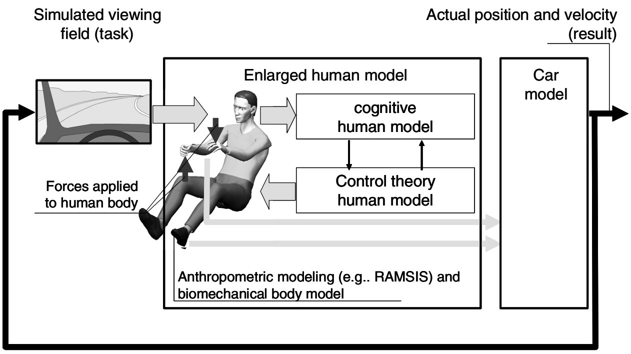

Fig. 11. Illustration of the combination of cognitive and control theory based human model

5 Conclusion

It was shown that the actual application of DHM is characterized by gravity in the area of anthropometry. Immediate research is done for applying forces and predicting simple motion. More complex motions give already the connection to modeling cognitive behavior. An essential concept in this connection is the idea of the leading body element. This represents so to say the connection between information processing and information transformation. Research of glance behavior is concerned with the connection between information reception and information processing. In the course of more and more possibilities to model this behavior the total process between information input and information output of the human operator can be represented by computer based models. That can serve as basis for "CAD experiments", by which the probable human behavior in context of a virtual task and a virtual environment can be calculated. So the influence of changing task and/or environment on the reliability of the human operator could be tested in a very early and not jet cost intensive phase of development. However, it is to be stated that such virtual experiments can done only in connection with few well known and well investigated tasks. An example is car driving. Presently in the context of the excellence research project "CoTeSys" of the Technical University Munich beside this mentioned example also for some application in assembly line and in the production industry such a modeling of human behavior is set in realizing.

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