

AN APPROACH FOR CONSIDERATION COMPETENCES OF ELDERLY PEOPLE IN THE DEVELOPMENT OF TECHNICAL SYSTEMS

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ABSTRACT

Elderly people are restricted in their efficiency due to the aging process. Technical systems provide a considerable potential to support the elderly in their domestic environment. It is important, to focus not only on aspects of ergonomics and operability, but the functionality of the products themselves should be stronger included in these considerations. To be able to support the designers in their complex development tasks at first typical age-related restrictions and medical conditions from an engineer's point of view will be described in the framework of this presentation, as well as, the influence of the biography on the use of technique will be analyzed. Considering these aspects an approach for classification and structuring can be derived, in which typical symptoms and their characteristics are related to appropriate product requirements.

Keywords: design for elderly people, requirements catalog of medical conditions, individualization of products

1 INTRODUCTION

The demographic change in central Europe proves to be one of the greatest challenges in the future. A multitude of problems is to be expected for which solutions not yet exist.

The idea of the Bavarian research association Fit4Age, founded by the Bavarian Research Foundation, aims to help moderate problems with the specific aid of technical systems. Partners at Bavarian universities along with industrial enterprises jointly search for innovative technical solutions to compensate individual performance restrictions and to improve the quality of life for elderly people.

In the past several approaches and guidelines were developed to consider individual performance restrictions in the development of technical systems [e.g. 1]. However, the found solutions were limited to aspects of the calendaric aging process. Restrictions in consequence of typical age-related medical conditions were not considered. Moreover, the known approaches focus primarily on the improvement of handling the systems and of ergonomic aspects. Last but not least this may be one of the reasons, why products "designed for elderly people" are not well accepted. With such products social discrimination is usually connected. However, technical systems offer a substantial potential to support elderly people in their domestic environment, in case not only the handling and ergonomics are given priority, but also the functionality of the products is stronger included in the considerations.

In the context of one of the projects (Fit4Product) of the research association the objectives are to develop methods which will permit that products are designed so individually that the user is enabled to keep up his or her quality of life as long as possible. Hence, elderly people will be supported both in their domestic and their work environment.

2 METHODOLOGICAL APPROACH

The idea is not new, to support elderly people with technical systems in the domestic and work environment. Many product ideas for seniors failed in the past due to the low acceptability of such solution by the user. Adaptations to the limited capability of the user takes place primarily on the interface between human being and technical system [1]. The focus was on handling and the design of handling elements. Their resulting noticeable design makes the individual's performance restrictions obvious, so that the use in general might entail social discrimination which eventually leads to rejection. Nevertheless, a number of products are distinguished by innovative functions, which

definitely implicate relief for the life of elderly people. Their utilization generally demands that the user is prepared to deal with a high system complexity. In principle this certainly would also be possible and feasible for elderly people. But apparently it does not work, as the entailed effort to study the manual and the appreciation for the usage, set in contrast an adequate benefit that justifies the costs for purchase and familiarisation for the user.

In the context of the subproject to be described it is essential to derive a methodology from this situation, which considers concerted the individual performance restrictions in the development of technical systems, so that elderly people get an effective assistance in daily life. It is necessary in this respect through approaches of individualization of the products [4] consider the different versions of performance restrictions, which result from the individual aging process itself in combination with several types of age-typical medical conditions. The degree of performance restrictions is additionally affected by the specific social situation of the concerned person. From this result different user habits and varying efforts of familiarization with the new techniques. Ultimately, the acceptability of solutions for innovative products depends to what extend it is managed to fix these aspects in the product development process.

Starting point of a thought for a holistic concept is the question, what is necessary to increase the acceptability of technical solutions. According to figure 1 three essential aspects described in the following are to be integrated in the classical product development process. Different studies from the field of psychology indicate, that new and innovative products can only be successful, if it is to manage, to involve potential users in the product development process [2] as early as possible. At the same time psychology provides a number of methodologies, how to include methods of user-participation in the different stages of a product development process [3]. The significance of user participation for the acceptability of technical systems is very important, however, it shall not be followed up in this contribution.

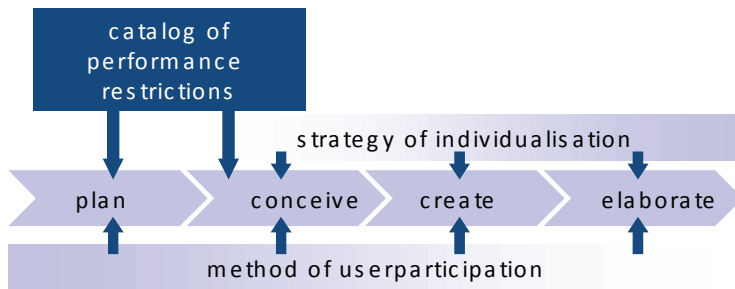


Figure 1: Framework of methods to consider individual performance restrictions with the objective to ensure acceptability of technical solutions

Integration of user specific demands and influences has to be considered over the complete product development process. The here presented description of age related performance restrictions and their resulting requirements have to be considered especially in the early stages. On the one hand they contribute to clarify the requirements, and on the other hand support the search for solution principles and their user shaped options.

Reasonable user participation, however, can only be integrated in the product development process, if there are already ideas and approaches that pick out the specific problems effectively. In regard to individual performance restrictions, to define and to characterize user groups, serves as a precondition in order to derive solutions. A structuring concept is to develop, that describes the performance restrictions and purposefully provides the engineer with all information of the development process. Based on a detailed description of performance restrictions it is necessary to prepare a product structure, so that the designer is able to tailor the product to the user for optimal aid in the sense of product individualization [4].

The adaptation of the product structure to the individual performance restrictions gain importance in the design phase. To be presented classification of performance restrictions should work foremost supportive.

This finally means for the engineer to offer a wide solution range for several sub-functions from which solutions according to requirements to be chosen and predefined product structures to be integrated. The derived strategies for individualization besides adequate approaches for modularization of the products primarily have to define interfaces between components respectively variants of components to ensure compatibility from a functional point of view. This paper, however, focuses on structuring and classifying methods of individual performance restrictions. An approach is introduced, which makes the necessary knowledge on performance restrictions available to the engineer and shows at the same time possibilities to compensate these. Simultaneously the classification can be of support in the medical and gerontological field, because it can additionally show the wide spectrum of technical feasibility.

3 STRUCTURING OF PERFORMANCE RESTRICTIONS

An essential condition for developing products for elderly people is to be able to describe typical human performance restrictions due to the aging process and age-related medical conditions. For this purpose a method is needed to “translate” medical and gerontological terms in a way, that enables the engineer to interpret these in terms of a specification for technical systems and, last but not least, to find solution approaches to compensate the restrictions.

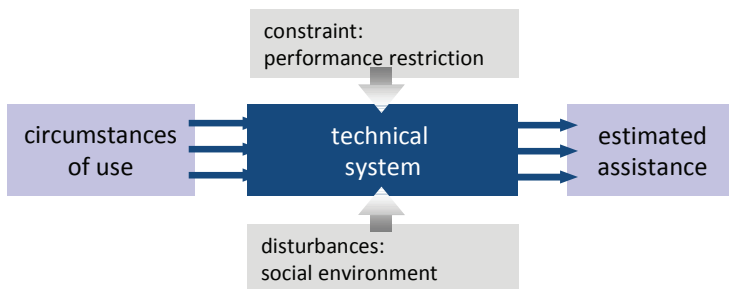


Figure 2: Situation of product development as a black box

An appropriate description and classification of performance restrictions, and its resulting requirements support the development process in two directions (figure 2):

- On the one hand we are able to deduce completely new product ideas which causally address a compensation of performance restrictions;
- Otherwise we found critical sub-functions, which need novel solutions due to performance restrictions.

Initial situation of every development task is the system purpose, thus, basically the necessity to offer an adequate problem solving strategy for a possible situation [5]. The capacity to act in a situation respectively the utilization of a technical system for problem solving depends not only on the basic efficiency of the system in the single situation. It is also essential to detect marginal conditions and disturbances which could influence the product usage. The important marginal condition in the context here is the user’s performance restriction. The utilization can be negatively influenced by the social environment and the corporate integration of the user. It can be derived from factors like educational background or social contacts how the user deals with his or her performance restrictions and with the offered assistance. To support the engineer in the product development the theoretical performance restrictions have to be prepared in a way that makes it possible to fulfil the above mentioned tasks and to contribute to the implementation of the development task. The problems in aging, which are basically formed by a medical respectively gerontological background and described with its wording, is to explain for engineering purposes.

The necessity of technical support for compensation can result here from the performance restriction itself. Otherwise, it can be a limiting criterion for the solution approach. The objective is to present the performance restrictions in a manner to derive special development parameters in order to support the solution finding.

For this a tripartite structuring approach is recommended, which is explained in the following.

3.1 Description of the medical point of view

At first it is to distinguish between the calendaric aging process and the age-related diseases as reasons for performance restrictions. Thus, performance restrictions result on the one hand from the age-related physical deterioration of humans, otherwise typical diseases increasingly appear which are connected to performance restrictions. The factual capability of an elderly person is, therefore, individual and depends on a number of criteria. Often, a so called multi-morbidity is observed. At the same time both the aging process and the diseases follow a chronological characteristic. These aspects have to be considered necessarily in the ascertainment of performance restrictions (figure 3).

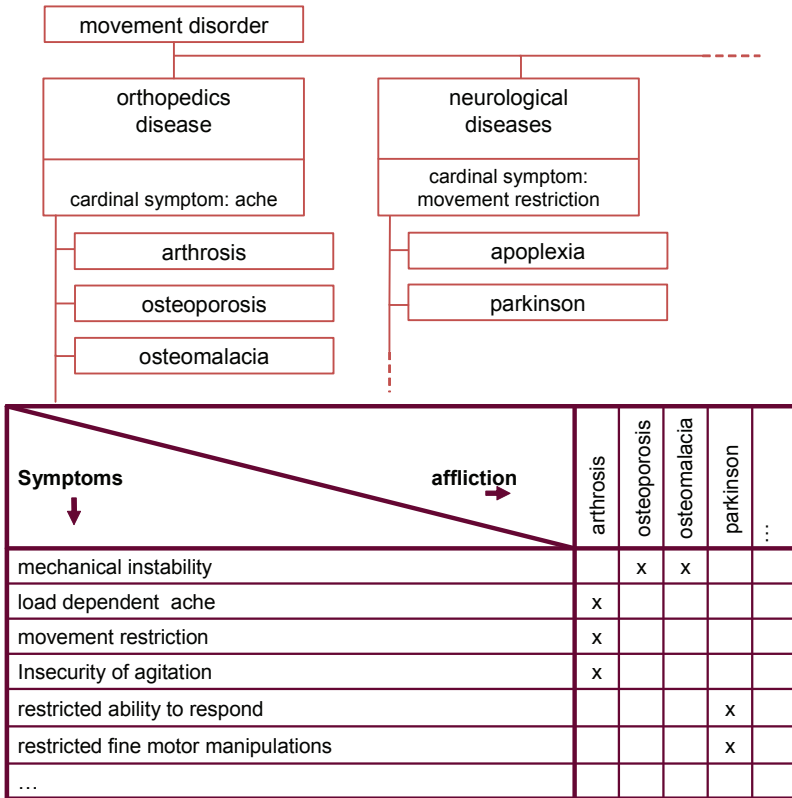


Figure 3: Analysis of age-related performance restrictions and medical conditions

To simplify matters in the first step it is to differ between age-related performance restrictions and medical conditions. Thereby, it quickly comes into view that symptoms repeatedly appear respectively may have different occurrences. By structuring symptoms and diseases in a matrix-like structure typical doublings of symptoms become apparent, from which finally performance restrictions result.

3.2 Bridge between the medical and technical point of view

In a second step it is necessary to search for principle compensation possibilities for performance restrictions. In an intermediate step additional to the symptoms precise performance restrictions are to derive, for which now the engineer together with the physician is able to search for compensation possibilities. It is important here to suggest neutral solutions of the compensation methods, in order to recognize them in the development process in terms of a sub-function.

The derived table in the first step (chapter 3.1) allows an additional further view (figure 4).

A detailed analysis of compensation possibilities delivers two results to the engineer:

- conclusion whether the compensation of performance restrictions requires a new product functionality (e.g. in case of the loss of orientation with Alzheimer's disease would a navigation

important for the engineer to find a coupling also between principle structuring approaches for technical systems and the compensation solutions and with it derive individual performance restrictions, as well. Basis for this approach could be the relatively general and from an engineer's point of view multidisciplinary reference architecture of mechatronical systems (figure 5).

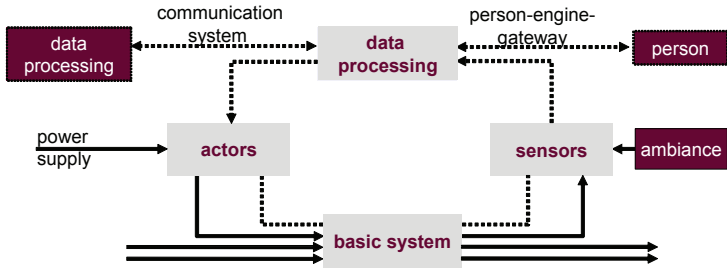


Figure 5: Universal reference architecture for technical systems [according to 6]

	motor	thumb manipulation	force assistance	reduced fine motor skills	...	sensory	retarded reaction	...	cognitive	...
reference architecture										
basic system										
robustness				x			x			
bearing strength										
stiffness										
barycenter										
...										
sensor system										
sensor system integration										
sensor system accuracy				x			x			
data capture		x					x			
sensor data fusion										
pattern matching				x						
...										
information processing										
...										
actuating elements										
input robustness		x		x			x			
input accuracy				x						
provision of information										
activity reaction										
action accuracy				x						

Figure 6: Assign compensation possibilities to the product structure

The different possibilities to compensate performance restrictions are assigned to the main components of the reference architecture, and if necessary, to a further sub-categorization of their

principle properties, which are important for the design of the components. Together with the tables and matrices from previous chapters a linkage with the performance restrictions is realized (figure 6). For the tabulation in figure 6 applies as well: when the matrix-like columns are set in contrast, not only dependencies between compensation possibilities respectively performance restrictions become visible, but it demonstrates also, that not only separate functions like the past focused handling functions alone contribute to the performance restrictions compensation, however, the functionality of the technical system itself holds significant potential. The aspect shall be explained with the example of navigation assistance for dementia patients: an interaction between the patient and the technical system can be realized via voice interface. With this not only the communication with the complex system will be easier, but it supports at the same time the limited retentiveness, since complicated handling procedures are not necessary.

3.4 Demonstration of the engineer's viewpoint

With the presented classification of performance restrictions (fig. 6) to the product structure it is initially possible to find determined solutions in individual sections. From the engineer's viewpoint ultimately each technical property, which is named in the first column of figure 6, has to be classified in concrete parameters to adequately define and describe these. With this the input accuracy can be described in detail, e.g. with handling forces, velocities, handling loops, etc. From the performance restrictions result for the sub-functions:

- Boundary parameters, which definitely result from the performance restrictions (degrees of limited mobility after an apoplectic stroke provide a limiting value for to be recorded path-time-behavior of a body part);
- Restrictions for the fulfillment of sub-functions (frequency of sensors adjust to reduced response time);
- Interconnections between different functions in terms of production rules are described (when pulse exceeds defined value, reduction of training-program is asked).

In the frame of product development these sub-properties are to allocate defined parameters which in turn depend on underlying performance restrictions. The engineer has to define (together with the physician) boundary values from the medical facts, which can be used in a function description.

While the description of age-related diseases and performance restrictions is build up based on an extensive literature research and by interviewing the appropriate specialists, it is much more difficult to derive generally reliable conclusions for the concrete allocation of parameters. These values are on the one hand formed by the user and his or her remaining capabilities, but they are also influenced by the system's purpose. In this area the outlined knowledge-database is to be completed gradually by know-how. A principle consideration to characterize performance-specific parameters results from the categorization of the system's purpose. If integrated functions, which are used for compensation of performance restrictions, are classified by

- support of remaining capabilities,
- compensation of lost capabilities,
- training of capabilities,

the range of values is defined more detailed.

A separation is not always clearly possible between the specification parameters and also between the classification parameters so that doublings can appear. This is accepted to allow both, physician and engineer to work intuitively with the knowledge-database.

4 ADVANTAG OF THE STRUCTURING AND CLASSIFICATION APPROACH

To converge to the manifold problems, which result from the demographic change in central Europe with the aid of technical systems, it is essential that engineers and physicians are able use the same language.

Such a mutual comprehension of problems, which elderly people can have in consequence of individual performance restrictions, shall be supported by the explained approach for structuring and classification. Only if both faculties work together with the same intention in order to solve problems, technical systems can really help elderly people to upgrade their quality of life. The structuring and classification approach can serve as a knowledge-database.

Finally, structuring is an important tool for the engineer to design products. As described in the preliminary chapter, the objectives of the explained approaches are to support elderly people with specific assistance-systems. Such an individualization of products is a great challenge in the field of product development, which requires new approaches and solutions especially for structuring and modularization of technical systems. For this, the described approaches should give the basis. As a result a database-system should be generated, which can be used as a handling respectively configuration catalog for products for elderly people with individual performance restrictions, both, for medical consideration (physicians, attendants, but also health insurances) and for the task to develop specific products for the problems described. It is essential in the next steps not only to implement the explained approach in a database-system, but also to improve and concretize the so far recorded performance restrictions.

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REFERENCES

- [1] Weißmantel, H.; Biermann, H.: Seniorengerechtes Konstruieren: SENSI – Das Design seniorengerechter Geräte. VDI-Verlag, Düsseldorf, 1995.
- [2] Hoffmann, E.: Consumer Integration in Sustainable Product Development. Bus. Strat. Evn. 16, S. 322-338, 2007.
- [3] Sarodnick, F.; Brau, H.: Methoden der Usability Evaluation – Wissenschaftliche Grundlagen und praktische Anwendungen. Verlag Huber, 2006.
- [4] Lindemann, U. / Reichwald, R.: Individualisierte Produkte – Komplexität beherrschen in Entwicklung und Produktion. Springer Verlag Berlin Heidelberg 2006.
- [5] Hubka, V.: Theorie technischer Systeme – Grundlagen einer wissenschaftlichen Konstruktionslehre. 2. Auflage, Springer Verlag Berlin Heidelberg, 1984.
- [6] n.n.: VDI 2206: Entwicklungsmethodik für mechatronische Systeme. In: VDI-Handbuch Konstruktion, Berlin. Beuth Verlag GmbH Berlin Düsseldorf, 2002.

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