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TRANSFER OF MECHATRONIC SYSTEMS AMONG DIFFERENT BRANCHES

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Summary: *The objective of knowledge transfer is, among others, transfer of ideas and information about technical products – technical object systems (TS) and their components among different technical branches. At present new possibilities based on Engineering Design Science have arised for knowledge transfer methodology when designing new TS, which has similar or the same required properties including functions as technical systems within the same or different 'source' branch or branches.*

1. Introduction to the theory

The traditional transfer of knowledge related to machine components is a well known concept at present. A wide range of different catalogues, cards, databases etc. have been developed and used for this purpose. These support the selection of an appropriate machine component, e.g. selection of hydraulic or pneumatic components, for the TS to be designed. This selection depends mainly on the abilities of the engineering designer. However, the problem of knowledge transfer among different branches can be aimed not only to select a suitable component from catalogue but also to use and transfer the function of a certain component or to transfer functional principle from one TS to another.

2. General knowledge transfer

The developed methodology of knowledge transfer (Formánek 2004) is based on general knowledge transfer among respective engineering design fields (Hubka 1996). Model of such transfer with support of the generalised Transfer Box (TrB) interface is based on fundamental structure of the level of Modular construction (Fig.1). Generally said the knowledge transfer of the relevant knowledge can be performed from branch X to branch Y or to another branches (including feedbacks to source branch X). Of course the transfer can be vice versa also executed from several branches to a single one.

During the knowledge transfer it is necessary to include also human´s own knowledge and at the same time to enhance these knowledge using feedback or to use SW expert systems, to add new knowledge to these systems. Thus such enlarged knowledge transfer contributes more to the complex upgrading of all its involved elements.

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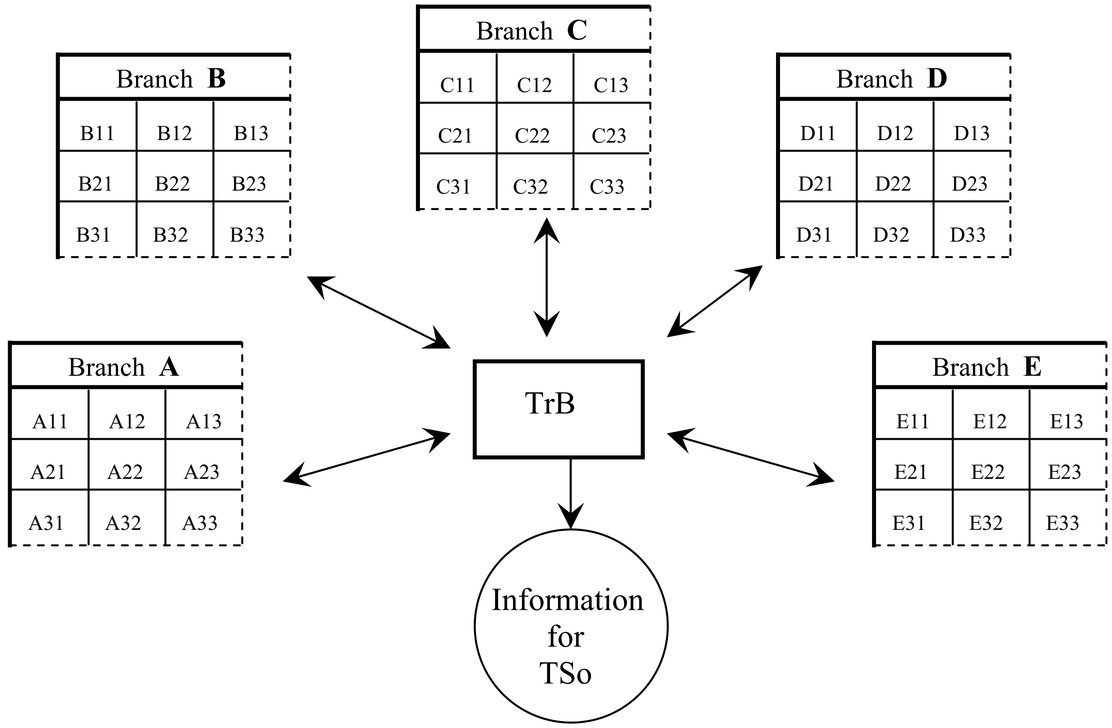

Figure 1. Model of inter-branch knowledge transfer

4. Applied knowledge transfer

4.1 Model of transformation system for knowledge transfer

A model of Transfer Box (TrB) for knowledge transfer (based on the model of transformation process) has been introduced for this purpose. This Transfer Box (Figure 2) can be understood as an information process interface between knowledge on TS_i and TS_o.

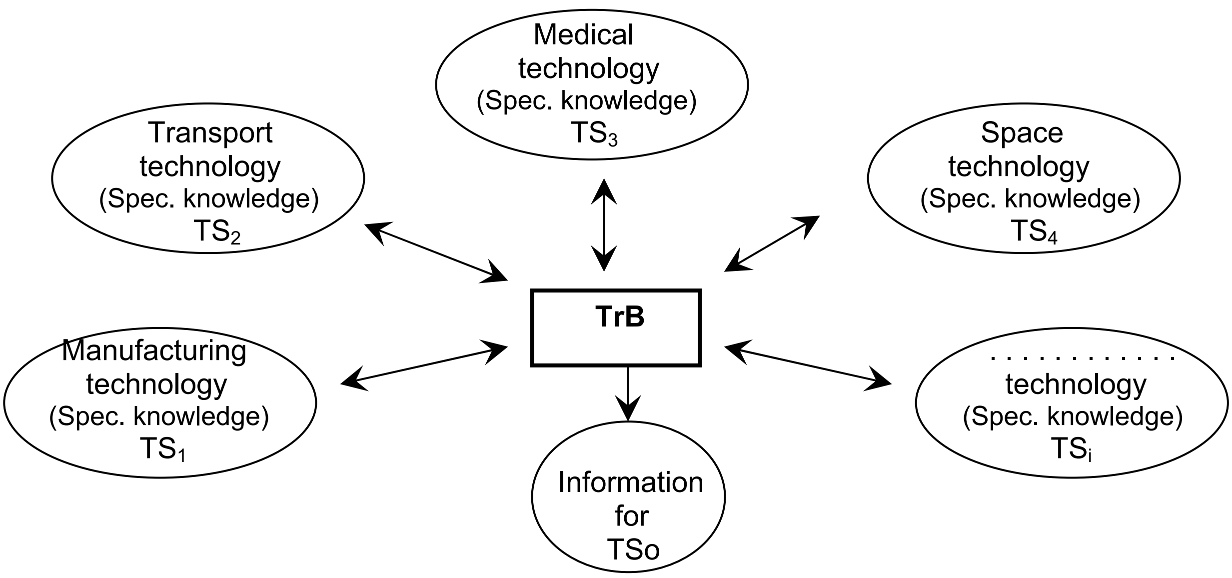

Figure 2. Model of transformation system

4.2 Hierarchical structure of the transfer processes within TrB

However, the knowledge transfer can be performed not only at the level of constructional structure, but also on the level of organ or functional structures as shown in Figure3.

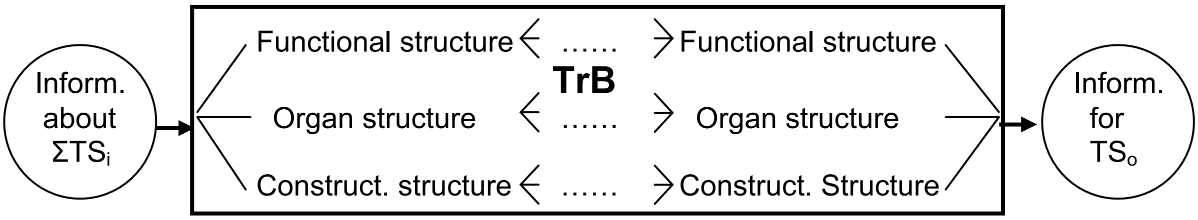

Figure 3. Hierarchical structure of processes within Transformation Box

The analyses of the ΣTS_i can be then executed with use of the mentioned morphological matrix from the level of constructional structures (elements&organs), through the level of organ structures (organs&functions) to the level of their functional structures (functions&effects). The reverse procedure can be applied for synthesis from functional level through the organ level to the constructional level. The system of these morphologic matrices is depicted in Figure 4:

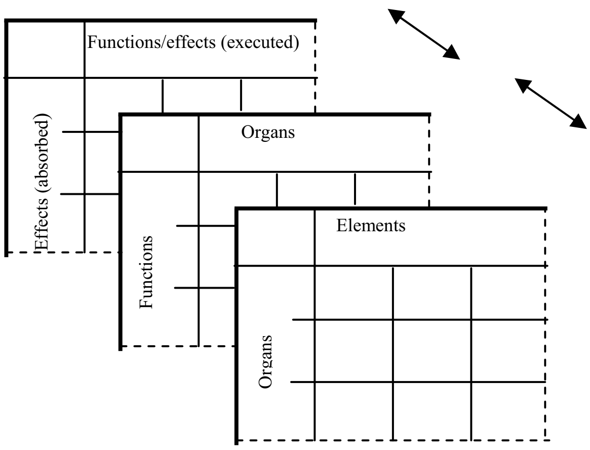

Figure 4. Morphological matrices for different abstract levels of TS structures

After analysis and completion of morphological matrix at all these abstract levels for ΣTS_i available, this matrices can be further improved by the next information items, which result from the following analyses of ΣTS_{i+j} or from experience of designers in the source areas as shown in Figure 5.

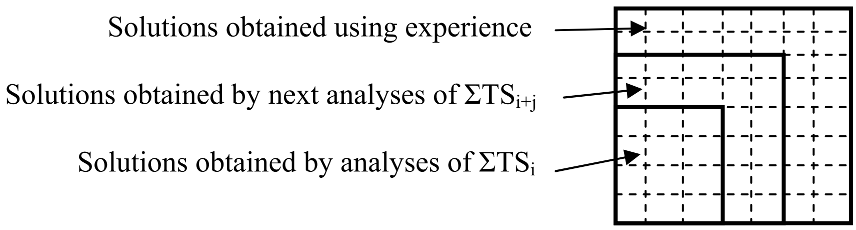

Figure 5. Principle of hypermorphologic matrix growth - adding information about the known solution

5. Case study - Applications

As mentioned above the developed methodology of knowledge transfer has been piloted on the engineering design of the use of camera modules in working space of machine during its operation using the area of manufacturing manipulation devices and of another areas (medical, security and etc.) as a source ones.

5.1 Project - enhancement of utility value of high-lift trucks

Increased productivity of work, careful handling in logistic centres, ergonomics and increased safety of personnel are trends of nowadays. This trend can bring inspiration and motivation for companies to look for new innovative solutions by the application of industrial cameras for easier control of load handling, for automation of loading and unloading by the aid of detection of line codes, for increased ergonomics at the workplace where electrical industrial trucks are applied. The use of high-lift trucks with industrial cameras for transport at small and medium distances is new. The camera thanks to its small size can be installed almost at any place of the truck (Figs. 6, 7, 8 and 9). The monitoring screen is placed directly to the visual field of the driver. The main advantage of this solution is the fact that design changes which are otherwise necessary to provide for maximum visibility of the driver (seat position, changes on protective frame and loading arm) can be omitted. At the same time productivity and transport capacity can be increased. Handling can be also easier and simplified by the additional light source given to the camera, e.g. during unloading and loading of containers, trucks and similar transport means. It is also possible to use wireless transfer of signal from the camera. This allows operator to monitor the whole handling process from control panel, and thus to know where the truck is or what really happens during loading/unloading at one or more trucks at the same time.

Figure 6. Camera on loading arm

Figure 7. Camera on upper frame of the truck

Figure 8. Camera view from the loading arm

Figure 9. Camera view from the upper frame

5.2 Project - monitoring of the process and space of the machine

The example of monitoring of the process and space of the machine by camera module connected to PC is demonstrated by functional handling equipment (Figure 10) where this minicamera will be used for the monitoring of working space of the machine (Figure 11) and or the identification of accurate location of the object to be handled. The first part of the project is similar as in the project aimed at the enhancement of utility value of high lift trucks (see 5.1.).

The second part of the project is aimed at the monitoring of correct position of the object. Economic aspects have been taken into account in the design ("Design for cost"). Camera module which is located on the handling arm (Figure 12 and 13) is 15 x 15 x 15 mm in size. This module (Figure 3) contains optical part, scanning CCD chip, circuits for signal processing and output part connected directly to the monitoring screen or to the card of A/D converter in PC or in notebook.

The camera scans the given object and the signal is digitalized via converter and then transferred to PC which evaluates the signal and determines correct position of the object or another required properties comparing them with installed program. If an error in location or in turning angle of the object is discovered, the handling device stops or is controlled in a way which provides its correct fixing by the jaws of handling device and then its transfer in accordance with the required values.

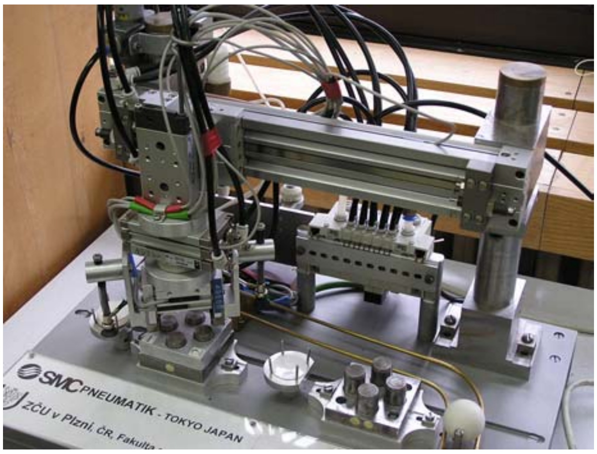

Figure 10. Handling device with PC control

Figure 11. Camera module on the handling arm

Figure 12. Detailed view of minicamera

5.3 Project - electronically controlled feeder

As mentioned above the developed methodology of knowledge transfer has been piloted on the engineering design of the electronically controlled feeder for disabled people using the area of manufacturing manipulation devices and of satellites TV as a source ones. When the complex analyses of the ΣTS_i available and SSI database have been completed the transfer of the required set of information to the area of health devices as in our case have been performed.

After engineering design of the feeder and subsequent evaluation of its components, an experimental model (Fig.13) has been manufactured and tested (Fig.14). Functional tests, were aimed at keeping and handling lightweight objects such as ballpoint pens, drawing aids, etc. These fully proved the functionality and capability of the feeder to perform all functions, which are required by its disabled user.

Fig. 13 Overall view of functional model of feeder

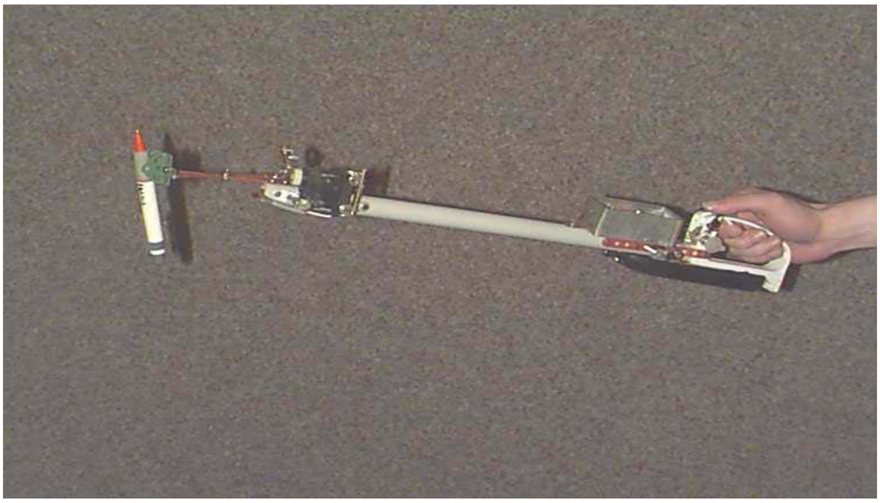

Fig. 14 Holding an object by the feeder

6. Conclusion

The objective of this paper is to present the developed methodology for knowledge transfer among different technical branches on levels of modular construction including those, which are apparently without any relations. Basic concept of the general methodology for transfer of entire engineering design knowledge among different technical branches has been outlined. The developed applied methodology can improve knowledge transfer in the course of engineering design of technical products. The methodology is suitable for computer and database processing.

These projects are designed on the basis of knowledge from transfer of knowledge at the levels of modular construction. The application of these minicameras is intended not only for the monitoring of working space of a machine but also for the identification of object to be handled, to determine its correct position including the transfer of video signal to control PC or to control centre. The use of very cheap camera modules with their accessories is shown on examples "Design for cost" criteria have been taken into account during design.

Systematic approach based on Engineering Design Science has been used to minimise possible mistakes and errors of designed technical systems (products) because even small matters neglected sometimes using intuitive design engineering can be punished by human health or life losses.

Further development of the methodology is intended in upgrading and more detailed description of the respective steps and in development of active supporting SW and other tools for engineering designers. This should help them more to find out easier new solutions and thus to achieve effectively innovations of the current products, which should have better potential to be successful on the market.

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