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Q:What is FBS?

A:

The Function-Behavior-Structure (FBS) model, proposed by Australian scholar John S. Gero in the 1990s, is a theoretical framework for systematically describing and analysing the design process.Gero's original purpose for the model was to understand the thinking process of design activities and to provide a clear logical structure for complex designs. The FBS model was initially applied to engineering design to help researchers sort out the path from design goals to final realisation. With the deepening of research, the FBS model has been gradually extended to architectural design, industrial design, and fields related to artificial intelligence. Its core idea, i.e. the dynamic relationship between function (F), behaviour (B) and structure (S), has become an important tool for analysing the design process and optimising design solutions.

During its development, the FBS model has undergone a transformation from a static framework to a dynamic model. Initially, the FBS model was mainly used to describe the basic elements and static relationships of design, but with the increase of design research needs, people began to pay attention to the iteration and feedback in the design process, which strengthened the dynamic characteristics of the FBS model. For example, by introducing a comparison between actual behaviour (Bs) and desired behaviour (Be), the FBS model is able to describe how a design solution adjusts its structure during the optimisation process to meet functional requirements. This improvement allows the model to better reflect the non-linear characteristics of the design process and to adapt to the design practice of multiple revisions in real engineering.

In addition, the applications of FBS models have been enriched by technological advances. For example, in the development of Artificial Intelligence Design Support Systems (AIDSS), FBS models have been used as modelling tools to simulate the designer's thought processes, to help generate design solutions and to perform performance evaluation. This combination has enabled FBS models to move from theoretical frameworks to practice, providing strong support for tackling complex design problems. With the rise of multidisciplinary collaboration and the need to design complex systems, the applicability and influence of FBS models are still expanding, providing an important reference for studying design thinking and improving design efficiency.

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Q:WHAT IS RFLP?

A:

Previous IT systems used in product development offered only limited support of Systems Engineering methods and data of the kind detailed e.g. in ISO Standard 10303 AP 233 “Systems Engineering”. This was due to the absence of an integrated information model spanning all product development phases and disciplines, and because many of the IT tools used were geared to specific application areas and consequently were unable to be integrated adequately [9]. For the first time, the so-called RFLP approach for developing mechatronic products could succeed in providing the called-for holistic support for design and development projects based on Systems Engineering . The acronym RFLP stands for Requirements engineering, Functional design, Logical design and Physical design (the 3D CAD model), and describes the process of systematic product development from system analysis to system development, comprising the descending branch of the aforementioned V model based on VDI Guideline 2206 “Development methodology for mechatronic systems” (VDI2206). The RFLP approach was first implemented as a basis for Systems Engineering in the conventional V6 PLM environment of Dassault Systemes. This approach was tested with the ENOVIA and CATIA systems, taking this solution as an example. Figure 1 shows the artifacts R-F-L-P, along with the development phases system analysis, system development and system integration as supported by the CATIA V6 CAx system and the PLM platform ENOVIA V6 for Systems Engineering.

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Q:What is RFBLP?

A:Referring to the FBS methodology to introduce the analysis of behavioural layer between the functional layer and the logical layer, and redefine the transformation process from the functional layer to the logical layer in the RFLP model, the whole transformation process from the functional layer to the logical layer after the expansion is divided into 11 steps, the specific process is as follows:

(1) Decompose the top-level function defined in the functional layer to get the sub-functions contained in the top-level function.

(2) Establish the internal functional architecture corresponding to the top-level function, and define the inputs and outputs of each sub-function.

3) Determine which behaviours are required to implement each sub-function.

4) Determine the data flow between the divided behaviours and establish the behavioural architecture corresponding to the top-level function.

(5) Verify the relationship between the behavioural architecture and the functional architecture, and determine whether the behavioural architecture can effectively support the implementation of the function.

(6) If the functional architecture and the behavioural architecture do not match, re-divide the behaviours.

(7) If the functional architecture and the behavioural architecture do not match, re-adjust or optimise the behavioural architecture.

(8) If the functional and behavioural architectures match, convert the behaviours into logical subsystems.

(9) Based on the transformed logical subsystems, establish the logical architecture of the logical system.

(10) Verify the logical architecture and behavioural architecture against each other to determine whether the logical implementation is consistent.

11) If the logical architecture and the behavioural architecture are not consistent, then re-divide the logical subsystems.

In the expanded RFLP model, the functional layer consists of the identified top-level functionality, its decomposed sub-functions, and the constructed functional architecture, focusing on system-level considerations.The behavioural layer, on the other hand, covers the segmented behavioural elements and the behavioural architecture used to describe behavioural interactions.The logical layer, on the other hand, contains logical subsystems and logical structures, where both the behavioural and logical layers are designed for objects.

The introduction of the behavioural layer analysis between the functional and logical layers is not just a simple model adjustment, but a strategy to enhance the digital twin model building process in general.This strategy focuses on delving into the specific behaviours required to implement each function, thus ensuring that the design process is not limited to understanding the static definitions of the functions, but goes deeper into how these functions are implemented through specific dynamic behaviours.In addition, by constructing behavioural architectures in a way that defines in detail the data transfer relationships between individual behaviours and explicitly expresses the mechanisms by which data is transferred within a function, it provides a richer and more dynamic representation of the data for digital twin modelling.At the same time, this approach pushes the designer to have an all-encompassing understanding of the mechanism by which the function is implemented, where every detail is taken into account, from the triggering conditions of the behaviour to its impact on the rest of the system.

Behavioural layer analysis prompts the designer to consider mapping relationships from the full picture of function implementation, rather than simply mapping sub-functions directly to logical subsystems.This approach avoids the problem of lack of detail and depth in traditional models due to lack of mapping depth.Through the exhaustive mapping of behaviour to logic, designers can construct digital twin models that meet functional requirements with a high degree of coherence and complexity, ensuring that the models are not only theoretically complete, but also highly useful and accurate in practice.

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