On a Formalization of the Test Control Problem

Bosikashvili Zurab, Kapanadze David, Zhvania Taliko, Kobiashvili Ana

Georgian Technical University, st.Kostava 77, 0175 Tbilisi, Georgia

Abstract.

The issues of the creation of the format automatic test control models are described. The general task of automatic generation of the control tests for various object areas, allowing the creation of the single formalization-based automatic test control systems, has been set.

Keywords: *formal models and control of their realization adequacy, automatic test control and knowledge control systems.*

Introduction

A modern development level of informational technologies allows deepening and widening researching, constructing and applying the informational models of different object areas (projecting of digital schemes, teaching process etc.). The control of models and adequacy of their realization always was regarded as an actual problem because checking of the adequacy of the model realization is an informal, difficult, multi-factorial task. Testing control is usually used to ascertain the adequacy. On the background of continually increasing the dimension of such problems, to make control more effective it becomes necessary to make testing control process automated. It is necessary to work out the principles of constructing the automated testing control systems and testing control methods for various object area formal models and adequacy of there concrete realizations. To organize the automated testing control it is needed to have tests with high completeness and efficiency. The problem of tests generating with such high quality is, in general, of combinatorial character and because of complicacy of models from object area and large dimension it is characterized with a large complexity, i.e. the linear growth of models dimension causes the exponential growth of a number of possible testing combinations.

There are known several methods [1,2,3] of generating tests. They are based on existed in combinatory testing theory. The traditional methods are not effective enough to solve the problems of automated generating of tests for models with high complexity and high dimension.

Format Models of Tests Control Process

To create heuristically effective methods of automated tests generation it is necessary to represent the knowledge about the object area. The knowledge representation models should be built in a way to simplify the automated test generation criteria and working out the estimation methods.

To check the adequacy of models and their realization because of variety of object areas, it's necessary to develop a general formatting for carrying out a testing control. A general scheme of actions needed to be done beginning from the idea of creating the system for any object area, till getting the concrete realization, may be expressed in the following way:

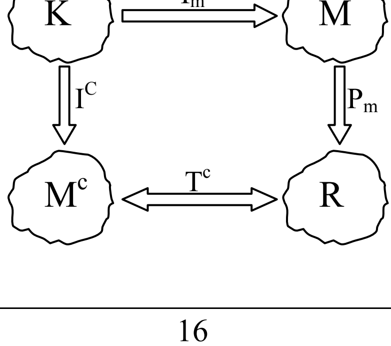

Fig. 1. The general scheme of the systems realization

Where K is the knowledge about the system by which the system functional destination is formed. The target functionality which must be implemented by the system may be described with a reflection operator F. Then the target functionality may be written down in such a way: $Y = F_k(X)$ where X is the set of possible impacts on the system, Y is the set of system reactions, and F_k – is the target reflection of K knowledge about the system. With the interpretation I of the knowledge K we may get the model $I_m(K) \to M$. According to this model, by means of reflection P_m we can carry out R concrete realization $P_m(M) \to R$. The components of the system R realization through failure, errors in constructing the model or any other unforeseen reasons may function not in a defined beforehand way but in an unpredictable way. Then the planned functionality of the system may be also changed and the system may carry out other functionality. In view of the fact that there may be a great number of system components functionality changing reasons, the target functionality realized by the whole system may be different, in other words, we can have several versions of the system r_j realization $Y = F_{r_j}(X)$. From these realizations one is the realization carrying out the true target functionality; others are incorrect or mistaken realizations.

Naturally the question is asked – to control which realization carries out the functionally adequate to target functionality $F_k(X) \Leftrightarrow F_{r_j}(X)$, or vice versa, the functionality, carried out by some concrete realization, is or not adequate to the target functionality which must be carried out by the system $F_{r_j}(X) \Leftrightarrow F_k(X)$. If the adequacy is not provided, it may be set a task to ascertain the source of errors or it may be evaluated the level of inadequacy by definite criteria.

To solve this problem we need using I^c interpretation to build such a M^c model of projecting system $I^c \to M^c$ in which it will be possible to provide and reflect the possible failure or errors. If M^c model carries out any i error, let's designate its corresponding model as M_i^c. Such a model will allow us to carry out the control of concrete realization and adequacy of the projecting system with high completeness.

To provide a control problem means to send the impact T^c to the concrete r_i realization inputs of the system, to get reactions $F_{r_i}(T^c)$ at the outputs of the system, to compare these reactions with the reactions to input impacts $F_{M^c}(T^c)$.

The testing control stems in various object areas are alike. In addition, such features increase usage of automated computing control systems. The difference between the systems used in different areas, first of all, is various investigated objects and the different terminology, used in control systems, but the models and evaluation criteria are similar in formalization.

Let us consider the interpretations of general scheme, formed above, and given tasks in two different object areas: in digital schemes projecting and in teaching some subject or discipline.

In digital schemes projecting K is the knowledge about the function that must be done by the projecting digital device. According to this knowledge, as a rule, it must be built a technical instruction in which the functions and requirements of the projecting device must be formed more clearly and concretely. With the interpretation I of these functions and requirements there will be constructed models M of the projecting device and there will be built projects in different ways, for example, logical, topological, tracing, and dispositional and other kinds of schemes of the digital devices. By reflecting the received P_m projects there will be get a concrete realization or a concrete device.

The mistakes made during projecting process or the failure in an element or elements of the device may cause to perform not a target function but some other function. As the number of possible mistakes and failures is great, we may suppose that we get many various realizations of the device. The purpose of the control problem is to define whether the device performs the desired target function or it performs some other function.

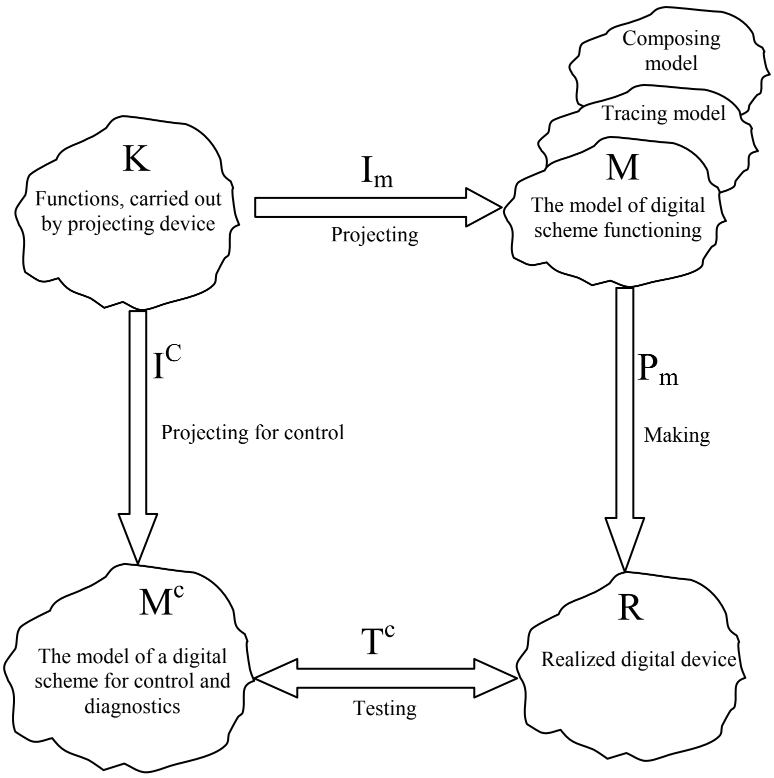

Fig. 2. The general scheme of the digital device realization

There are known various methods of modeling the functioning of digital devices [2, 4], but if these models are used in the process of controlling and diagnosis, then there must be other requirements. That's why we should be able to model all possible failure and mistakes. In order to increase the effect of solving control and diagnostic problems, as a rule, M and M^c models are different. The general scheme of actions, required for projecting and control of digital devices, in terms of this object area, is shown in Figure 2.

During teaching some subject or discipline K is the general knowledge about the subject to be learnt. On account it, the tutor with I interpretation will form the instructional course. During forming the course it must be provided the volume and depth of the target subject, the number of hours to be needed for teaching, it will be determined the structure and contents of the course. It must be said that this process is a practically not investigated and difficultly formalizable process and it is defined with the professional and experience level of the tutor or expert in this area. The formalization of instructional course is generally connected with formalization of knowledge representation that is not solved for the present [5]. In fact, the tutor chooses the instructional course from the instructional subject area, i.e. he/she with his/her interpretation builds M model. The course may be represented by means of a book, a conspectus, multi-medial means or other materials. According to the formed course there will be realized teaching P_m of individuals (pupil, student, post-graduated person and others), who will acquire R knowledge. To lead the teaching process effectively greatly defines the quality of the learnt by the individual, material, but these questions are out of our research area borders. During teaching each person individually adopts the material from the course. That is why the level of their knowledge is individual and different.

In order to check the level of adopted by the individual material or the level of adopted knowledge, it's necessary to estimate all the individuals with the same criteria or control. With this purpose the individuals are tested, certificated, questioned or controlled in other ways. Choosing the control questions is as difficult and informalizable process as composition the instructional program. That's why we may need another model M^c of material to provide control process. It will ease the process of question forming. On the basis of received questions it is possible to compose and give the systematic character to the definite set of questions or tests. The function of these tests is to range the knowledge level of individuals.

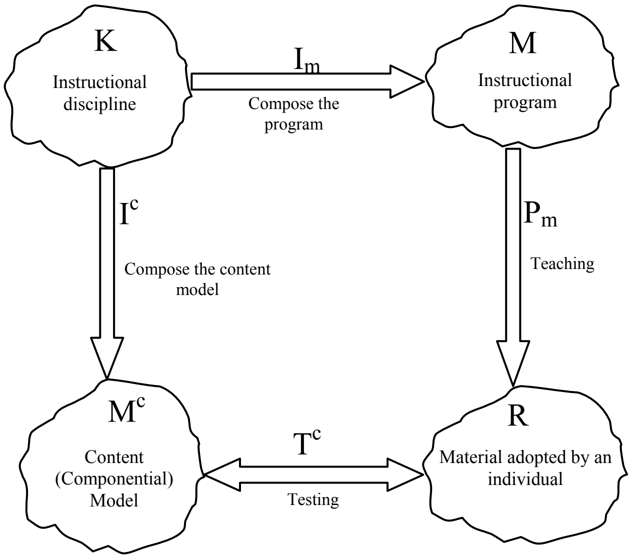

Fig. 3. A general scheme of adopting instructional course

The scheme of actions needed for teaching and controlling process of some discipline in terms of object area is shown in Figure 3.

In conclusion, the control tests synthesis task for some object area object may be represented as a formal model of the following kind:

$$T_M = < S, S_0, F, G >,$$

where S is a space of states of an object, $S = X \times U \times Y$.

In this expression X is a set of input impacts, U - is a set which reflects internal states of the object, y is a set that reflect reactions of an object, S_0- is an initial state of object states. E represents a set of operators which reflects the changes in the state space of an object $F : X \times U \times Y \to U \times Y$, or F is a modeling operator. G is a set of target states and it may be represented as: $G = \{S(B(s), s \in S\}$, where B is a predicate which is built up in according to the criteria of choosing tests.

A general model of carrying out the test control process in various object areas was developed which allows working out the effective heuristical methods of automated tests generation.

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