The application of the theory of dynamic systems to software quality estimation

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Hardware and software are considered from the point of view of the theory of dynamic systems. It has been shown that a program may be considered as dynamic system placed into the phase space of the program variables. The theory of dynamic systems as applied to programming allows to classify programs revealing the important quality indices of the program products which are related to the basic concepts of the ergodic theory as well as to that of information and informatics. As a program is run, possibilities (complexity) of the computer may be evaluated and important quality indices of the hardware may be appreciated from the point of view of the programming itself. This approach lets also separately evaluate the quality of both hardware and software.

Results

Let *NM* be the maximum value applied to computer. We consider a space having the measure (M,σ,μ), where *M* is a space using as its elements the real numbers applied to computer, i.e. σ is σ-algebra of the whole sub-set *M*, *M*={-*NM*,…,0,...,*NM*} and μ is measure of normalization of *M*, i.e. $\mu(M)=1$ and all the points are equiprobable.

Let *T* be a cyclic substitution for *M*. Then, according to [Billingsley, 1965], is an ergodic transformation *T* generates the monoparametric group of automorphisms $\{T^t\}$ of the space having the measure (M,σ,μ), i.e. it generates the dynamic system $\{T^t\}$ for (M,σ,μ) [Cornfeld, Sinay, Fomin, 1980]. Thus, the following affirmation is valid.

Affirmation 1. The set of all the appropriation operators assigned for the set *M* permit partition to equivalent classes for which a group structure (monoparametric) may be introduced. This dynamic system (group of automorphisms) is ergodic.

If the program includes more than one variable, the direct product of the dynamic systems must be taken thus enunciating again the Affirmation 1 as follows.

Affirmation 2. In the case *N*>1 of variable sets of all the appropriation operators assigned for the set $M\times...\times M$ (*N* co-factors), partition to equivalent classes is admissible to assign a dynamic system being equal to the direct product of the dynamic systems acting on the space (M,σ,μ). This dynamic system is ergodic.

Since the program may be considered as a sequence of appropriation and control operators, from the Affirmation 2, the following conclusions may be obtained:
- to a certain run of an arbitrary program a certain space automorphism (M,σ,μ) corresponds,
- to every space automorphism (M,σ,μ) not more than one even number of the programs run corresponds.

Thus, programs may be considered as dynamic systems and, consequently, to the software analysis methods and results obtained from the theory of dynamic systems may be applied. In particular, application of the theory of dynamic systems in programming allows to classify the programs to reveal the important indices of the program product quality which are related to the fundamentals of the modern physics. Besides, according to the program run, conclusion may be done on the computer complexity being so an important index of hardware quality from the point of view of the programming itself, and a separate assessment of the hard- and software quality may be carried out.

Conclusion

The above approach permits to evaluate separately the hard- and software quality. It is obvious that, from the point of view of the theory of dynamic systems, approaches are marked as related to the separate assessment of the hardware and software quality. To the assessment of the software quality, such indices may be related as the information entropy *IE* and the fractal dimension *d*. To the assessment of the hardware quality J_1 (J_2) and μ_1 (μ_2) may be referred. Thus, *IE* and *d* represent a quality index of software being J_1 (J_2) and μ_1 (μ_2) - a quality index of hardware.

So, such an approach from the point of view of the theory of dynamic system lets basically separate the quality indices relating them to those of software and hardware, as well as to the mixed ones, i.e. to such indices which are the same time of hard- and software. For instance, reliability may be related to the mixed indices.

The above approach to programming from the point of view of the theory of dynamic systems allows to see the ways of solving of such important indices as the quality indices of hardware and software which are based on the fundamental concepts of the modern physics, and the classification of programs. In the future, disparalleling of the programs will be added to the above indices. All the stated above seems to permit soon to pass from consideration of the programming as an art to its consideration as a science based on the fundamentals of the ergodic theory, theory of information and informatics.