NEW MATHEMATICAL METHODS FOR PSYCHOPHYSICAL FILTERING OF EXPERIMENTAL DATA AND THEIR PROCESSING

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This article, which is devoted to new mathematical methods for psychophysical filtering of experimental data and their processing, may be regarded as a development of ideas of Ref.1 on the experimental detection of interactivity in complex systems. The main innovation is that a psychophysical filtering is used consistently now for such detection.

1. Basic procedure. Let us consider a natural, behavioral, social or economical system $S$. It will be described by a set $\{\varphi\}$ of quantities, which characterize it at any moment of time $t$ (so that $\varphi = \varphi_t$). One may suppose that the evolution of the system is described by a differential equation

$$\dot{\varphi} = \Phi(\varphi)$$

and look for the explicit form of the function $\Phi$ from the experimental data on the system $S$. However, the function $\Phi$ may depend on time, it means that there are some hidden parameters, which control the system $S$ and its evolution is of the form

$$\dot{\varphi} = \Phi(\varphi, u),$$

where $u$ are such parameters of unknown nature. One may suspect that such parameters are chosen in a way to minimize some goal function $K$, which may be an integrodifferential functional of $\varphi_t$:

$$K = K([\varphi_\tau]_{\tau \leq t})$$

(such integrodifferential dependence will be briefly notated as $K = K([\varphi])$ below). More generally, the parameters $u$ may be divided on parts $u = (u_1, \ldots, u_n)$ and each part $u_i$ has its own goal function $K_i$. However, this hypothesis may be confirmed by the experiment very rarely. In the most cases the choice of parameters $u$ will seem accidental or even random. Nevertheless, one may suspect that the controls
are interactive, it means that they are the couplings of the pure controls \( u_i \) with the unknown or incompletely known feedbacks:

\[
u_i = u_i(u_i^o, [\varphi])
\]

and each pure control has its own goal function \( K_i \). Thus, it is suspected that the system \( S \) realizes an interactive game. There are several ways to define the pure controls \( u_i^o \). One of them was proposed in Ref.1. It is based on the integrodifferential filtration of the controls \( u_i \):

\[
u_i^o = F_i([u_i], [\varphi]).
\]

To verify the formulated hypothesis and to find the explicit form of the convenient filtrations \( F_i \) and goal functions \( K_i \) one should use the theory of interactive games, which supplies us by the predictions of the game, and compare the predictions with the real history of the game for any considered \( F_i \) and \( K_i \) and choose such filtrations and goal functions, which describe the reality better. One may suspect that the dependence of \( u_i \) on \( \varphi \) is purely differential for simplicity or to introduce the so-called intention fields, which allow to consider any interactive game as differential. Moreover, one may suppose that

\[
u_i = u_i(u_i^o, \varphi)
\]

and apply the elaborated procedures of a posteriori analysis and predictions to the system.

In many cases this simple algorithm effectively unravels the hidden interactivity of a complex system, however, sometimes it does not work. Therefore, more sophisticated procedures should be applied. One of them will be described below.

Let us consider an interactive game with states \( \psi \) and interactive controls \( w = (w_1, \ldots, w_m) \) so that the evolution equation has the form

\[
\dot{\psi} = \Psi(\psi, w).
\]

The interactive controls are the couplings of pure controls \( w^o = (w_1^o, \ldots, w_m^o) \) with the unknown or incompletely known feedbacks:

\[
w = w(w^o, \psi).
\]

Often such interactive game is a game of a real human person and the interactivity is caused by the coupling of conscious and subconscious behavioral reactions.

Let us consider the integrodifferential nonlinear operator, which will expresses the pure controls \( w^o \) via \( u \) and \( \varphi \):

\[
w^o = W([u], [\varphi]).
\]

In the simplest case one may put

\[
w^o = W(u, \varphi).
\]

The pure controls \( w^o \) realize a scenario for the interactive game and it becomes a performance.

The integrodifferential filtration should be applied to \( w \) instead of \( u \) now:

\[
u_i^o = F_i([w], [\varphi], [\psi]).
\]

We suspect that \( u^o = (u_1^o, \ldots, u_n^o) \) are pure controls for \( u = (u_1, \ldots, u_n) \). It means that

\[
u = u(u^o, \varphi)
\]

and the explicit dependence is unknown or incompletely known. Because we use a human person, the whole procedure realizes a psychophysical filtering of the experimental data.
2. Psychophysical engineering.

The basic procedure, which is described above, admits further improvements, which are based on the ideas of automata theory and form the psychophysical engineering.

First, let us mark that an interactive game may be regarded as an infinite automata with continuous time. Therefore, one is able to consider a composition of interactive games. It means that the interactive controls of one game are used as pure controls for another one. Certainly, some integrodifferential transforms of controls (analogous to one described above) may be used between output of one game and the input of another to glue the games. Such transforms are defined by the known integrodifferential nonlinear operators. Of course, such operators are reduced to functions in the simplest cases.

Such glueings of interactive games allows to construct very sophisticated objects started from only few basic interactive games. Combined with the basic procedure above such psychophysical engineering becomes an effective tool for the unraveling of interactivity in complex systems. Concrete parts of the whole construction may be realized either by one human person or by their group. Of course, external interactive phenomena of non-human nature may be used also.

The simplest interactive games, which may be used for the psychophysical engineering, are the visual (or general perceptive) games. However, it is difficult to parallelize such games so it is reasonable to interiorize the behavioral reactions, which are generated in such games. It means that the functional dependences between pure and interactive controls are remebered and reproduced by the person without any external or even internal visual image.

Of course, the process of psychophysical engineering may be regarded as a tactical procedure [2] and may contain the intuitive subconscious steps. Therefore, a psychophysiological training may sufficiently enlarge the capabilities of a person to perform the psychophysical engineering. The group trainings are effective when groups are used. Personal abilities to adapt the external interactivity of non-human nature are also very essential.

References

[1] Juriev D., Experimental detection of interactive phenomena and their analysis. E-print: math.GM/0003001.

[2] Juriev D., Tactical games & behavioral self-organization. E-print: math.GM/9911147.