INSTRUCTIONAL FEEDBACK BASED CONTINUOUS EVALUATION. AN ANALYSIS FROM THE CONTROL THEORY POINT OF VIEW

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Abstract

The instructional feedback model establishes a parallelism among a feedback control automated system and the relationships between the teacher/instructor and the student/learner. In such a model the teacher/instructor is assumed to be the controller or provider of energy to the system to be controlled (the student's/learner skills and competences on a specific subject). The instructional feedback is a closed loop model that relies on receiving feedback from the students/learners and to generate different actions to modify its learning performance. In this communication the idea of instructional feedback is reviewed and slightly reformulated highlighting the necessity and importance of another feedback loop that has to be closed on the student/learner side as well as providing the means for this. On the conventional instructional feedback model the feedback is received at the teacher/instructor side, whereas it is, on the author's opinion, at the student side that has to be closed in order to be effective.

Keywords - Instructional feedback, Continuous Evaluation, Feedback based mechanisms

1 INTRODUCTION

Feedback is a by now a well established mechanism in engineering applied to develop automatic control systems [1, 2]. The main benefits of feedback come from the generation of an error signal among the desired target and the observed output. The main actors of a feedback control system are the process or system to be controlled and the controller. The controller acts on the system by generating appropriate control actions on the basis of the observed feedback error (target – observed system's output). As a familiar example, we can consider a room temperature control where on the thermostat we set the desired temperature for the room (this is the target temperature). The temperature is sensed (observed system's output) by and transferred to the thermostat that accordingly adjusts the heating/ventilating system in order to achieve the desired target temperature.

The instructional feedback model [3] establishes a parallelism among the previously described situation and the relationships between the teacher/instructor and the student/learner. In such a model the teacher/instructor is assumed to be the controller or provider of energy to the system to be controlled (the student's/learner skills and competences on a specific subject). The instructional feedback is a closed loop model that relies on receiving feedback from the students/learners and to generate different actions to modify its learning performance.

In this communication the idea of instructional feedback is reviewed and slightly reformulated highlighting the necessity and importance of another feedback loop that has to be closed on the student/learner side as well as providing the means for this. On the conventional instructional feedback model the feedback is received at the teacher/instructor side, whereas it is, on the author's opinion, at the student side that has to be closed in order to be effective.

This approach has been tested on an Engineering degree when teaching Signals and Systems to Computer Science students. What is presented here is, after a revision of the instructional feedback model, how this model is modified and implemented. The method has been applied during two years and student performance is compared with previous years. This alternate proposal for the instructional feedback model constitutes, on the authors opinion, an alternative way of looking at continuous evaluation where the main goal is not just to asses the student/learner as he progresses along the syllabus but to provide means for *self*-learning and motivation on the topics where more attention is required.

2 FEEDBACK CONTROL

Feedback control is a very important theory in scientific applications. For instance, it is widely used in various dynamic systems, such as the temperature and humidity regulation in houses to provide comfortable living space. The system generally means some physical entity on which some action is performed by an input. The system reacts to this input producing an output. A dynamic system is a system which phenomena occur over a time-domain.

Fig. 1 shows a typical feedback control system, which is composed of controller unit and plant unit. The controller unit can affect the plant unit behavior. That is, the controller output determines the plant output. One controller must be designed to reach the system goal. The controller type may be proportional (P), integral (I), or derivative (D), or may be a combination of any of these three types. The input of the whole system is called a reference value. The controller output is called a manipulated variable, and the plant output is called a controlled variable.

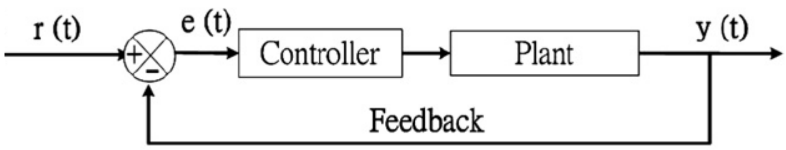

Fig. 1 Feedback Control system

3 INSTRUCTIONAL FEEDBACK

Instructional feedback (IF) is presented as the application of control theoretic concepts to the teaching/learning domain. The basic diagram showing the different players is shown in fig. (2).

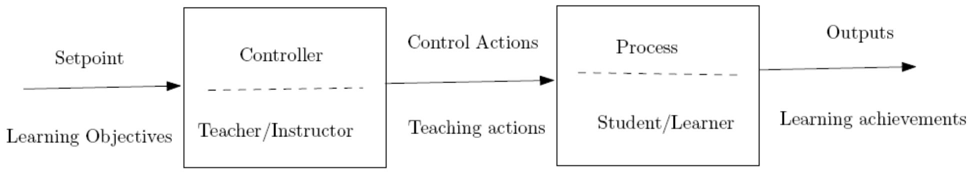

Fig. 2 Open-loop instructional/control system

This figure puts into place the main elements of the teacher/learner collaborative system and its counterparts from the process control system domain. As it is shown, this system corresponds to what it is known as an open-loop control system. The control system as a whole has as its main goal the achievement of a set of learning outcomes by the student (the learner). These learning outcomes enter into the teacher or instructor that has to generate the appropriate set of teaching actions that will drive the learner to the achievement of such learning outcomes.

As it has been mentioned, from the point of view of control systems theory, this scheme corresponds to an open-loop system. This means the instructor generates the teaching actions on the basis of the learning outcomes but not on the actual achievement of the learning outcomes by the learner. Therefore the teaching actions are a predefined set of actions that are conceived a priori and are independent of the behaviour exhibited by the controlled process (in this case the learner). The open-loop approach for controlling a system is recognized, due to several reasons, as an inefficient way to control a system [1], [2].

The drawbacks of the open-loop approach to control leads to a more efficient approach: the one based on closed-lop feedback control. On this approach the controller takes decisions on the basis of a continuous monitoring of the process outputs. Therefore new control actions are generated in case the previous ones are not efficient enough. At this point the decision to close the loop leads us to the feedback based Instructional Learning system of fig (3).

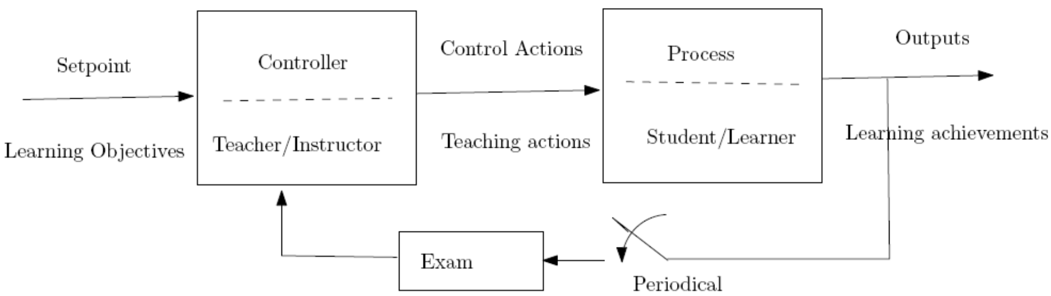

Fig. 3 Closed-loop instructional/control system

As it is usual the controller is informed by a measure of the actual output of the process. It has to be noted, however, that the feedback mechanism has associated a sampling time that makes it to operate on a periodical basis. The consequence of such fact is that the loop is not closed continuously but just at some precise instants (from the instructional point of view the times where evaluations or exams are performed). Within the control theory domain these instants are called sampling instants. Our next ask will be to reinterpret some well known teaching/learning models in terms of the feedback control system, being the main task to show that the real use of feedback is a rather misunderstood concept.

First of all it has to be made clear that in a feedback control system, the control actions are constructed on the basis of previous history of process output and previous control actions. This fact allows the controller to evaluate if the output of the process is conducted on the right direction. On a more formal way, let us assume the time evolves according to a certain time unit, T_m (one day, one hour, one week, etc). That way, after *k* time units we can think of a vector of length *k* containing the values of a variable of interest in each one of such time instants. For example, if we denominate the learning outcomes at time instant k as r_k, vector $\mathbf{r_k}=(r_o,\ldots r_k)$ will contain all previous values. Along the same lines denominate $\mathbf{u_k}=(u_o,\ldots u_k)$ and $\mathbf{y_k}=(y_o,\ldots y_k)$ the control or teaching actions and the learner outputs respectively. Based on these definitions, a feedback based control action can be written as

$$u_k=\mathbf{f}(\mathbf{r_k},\ \mathbf{u_{k-1}},\ \mathbf{y_k})$$

Whereas in case no use of information regarding the values of the process output on previous instant are considered, the control action can be written as a functional of the form

$$u_k=\mathbf{f}(\mathbf{r_k},\ \mathbf{u_{k-1}})$$

Obviously, the sampling action corresponds to the execution of one or more evaluation tasks that will report the instructor information about the student progress. On this respect sampling can take various forms depending on the evaluation performed.

3.1 End-of-term evaluation

To perform an exam or evaluation at the end of the term (EoT) is a classical approach that is by now being replaced by continuous evaluation. Within the EoT approach the students are examined at the end of the teaching period. On the basis of this evaluation the students are assessed. In this case, even the instructor receives information about the student progress; this information is acquired at the end of the term. Therefore as all the teaching (control) actions are generated independently of such progress, this is an open-loop based instructional system.

There is, however, one possibility for closed-loop actions within the EoT framework if we consider a different time scale: say a term-to-term time scale. At this new time scale we can apply feedback by learning from one term to the next one. Therefore teaching actions can be updated or modified in order to be more efficient and better accomplish the learning outcomes. This framework is more or less the usual one we can find in our faculties but, is feedback really applied? It is the authors opinion that feedback is not applied, as teaching actions are basically the same (or at least its effectiveness not revised) from one term to the other).

Another observation from a more strict control theoretic point of view is that form one term to the other the system to be controlled changes: the students are no longer the same. So if we are controlling another process the problem is different from the previous one. Therefore, strictly speaking, feedback is not possible.

3.2 Continuous evaluation

Continuous evaluation (CE) is recognized as an improvement over its EoT counterpart. In such case, the periodical application of evaluation actions reports the teacher valuable information about the student progress. Again, to fully explode the potentials of feedback an update of the teaching actions should be done after each evaluation. This explicitly means that the results of an evaluation should be taken not only to assess the student's progress but to allow the instructor to evaluate the effectiveness of the applied teaching actions. This second observation is a missing term that the authors think could help in improving the quality of teaching.

There is, therefore, a misunderstanding on the conception of CE as a way of introducing feedback into the teaching process. On one side three is the need to generate information and this is accomplished by the different evaluations periodically performed. On the other side there is the use of such information. Two potential users of such information are identified and, therefore, two feedback loops can be closed.

- Feedback loop from the instructor/teacher side: as it has been mentioned before, this implies the evaluation of the effectiveness of the applied teaching actions and suggests improvements for a more effective teaching.

- Feedback loop from the learner/student side: from the periodical results the student should perform a self-evaluation of the way the study is conducted. How the study habits should be changed in order to take more profit of the educational resources.

The recognition of these two feedback loops and how to take advantage of each of them is a potential way of improving actual teaching culture.

4 CONCLUSIONS

With the Feedback Closed Loop based Instructional System (FCIS) we are faced with a conceptual model, an approach with powerful possibilities that characterizes the different elements of the instructor/learner system, by showing its role as well a sits relation with the rest of elements of the system.

The benefits of a control system based on feedback are well known and recognized. To take advantage of such benefits on an educational framework, the FCIS can be adopted. This communication has analyzed the instructor/learner system and put it within the framework of a control system. Commonly used approaches for teaching are analyzed and identified as truly open-loop schemes. Therefore the potentials of feedback are not fully exploited. This model suggests how the benefits could be improved and points on the direction of a more active controllers: this is an active instructor that should adapt teaching actions on a continuous basis by taking into account the actual progress of the student.

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