A Prototype of Modeling as a Continuum of a Translation Process

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[ABSTRACT]
Forrester, the founder of System Dynamics insisted that the industrial dynamics would help expand the automatic decisions. It is expected that management science should gradually expand its area from art to science. For this aim, it is important to understand the complexity about processing an event. This paper will show a simple prototype of modeling as a continuum of translating each stage, using some simple examples.

Introduction

Forrester, the founder of System Dynamics insisted that the industrial dynamics would help expand the automatic decisions. It is expected that management science should gradually expand its area from art to science.

Nowadays many softwares such as STELLA, Powersim, and Vensim etc. enable us easily to build a diagram, but we have to convert our thought in a natural language into a System Dynamics diagram. During this process, most parts of model-building processes rely on art even today.

Generic models (Richmond) and Archetypes (Kim, Senge) give us very useful building blocks for building a model as well as learning an event. However it is important to notice that there is a continuum of a human image about an event, its expression in a natural language, its causal loop, its diagram, and its equation model. If a model-building process is considered as translating each stage into the next stage of the continuum, it would be possible even for a beginner to finish from one end to the other quickly. Toward this aim, this paper will show a simple prototype of modeling as the continuum of translating each stage, using some simple examples. As a result, causal loop (Coyle) will also be examined for its extension.

A Continuum of Modeling Process

Modeling process starts from an image about an event . This image is associated in words using a natural language at Step 1 in Figure 1. The words are converted into causal loops using a causal loop at Step 2. These causal loops are converted into a diagram using graphic symbols at Step 3. Finally the diagram is converted into an equation model for computing at Step 4. These processes are recognized as a continuum of translating the former expression into the latter one sequentially.

1.jpg

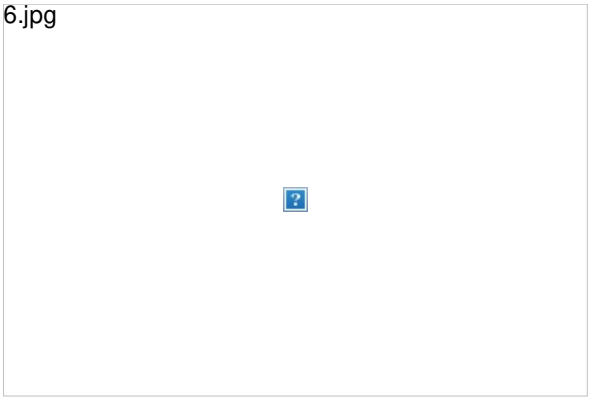
Today, graphical user interface softwares such as STELLA, Powersim, and Vensim etc. enable us easily Step 4, while the other steps of Figure 1 rely mainly on human side. Generic models and Archetypes focus on human understanding of an event in order to enhance processing of Step 1, Step 2, and Step 3. Generic models and Archetypes do not automate these steps. This paper, thus, focuses on the relationships of these steps in order to get insights for the aim of automating this continuum process for modeling.

A Prototype of Modeling as a Continuum

This section shows three examples of a prototype of modeling as a continuum of a translation process: 1) an example of positive feedback, 2) an example of negative feedback, 3) an example of positive & negative feedback. In each example, some important characteristics of causal loop related with natural language are found.

1) As an example of positive feedback, let's think about a thing which grows by itself. At Step 1 this image can be converted as the Compounding Process in a natural language: "When a thing increases, this growth leads to further developmental changes." This is translated into causal loop I of Figure 2.1. This loop is refined into causal loop II by adding Action to Thing. This new loop II is recognized as causal loop III using Stock and Flow for the System Dynamics. In the case of a bank balance, Stock is a bank balance and Flow is an interest income in causal loop IVa. An interest rate is not a part of a loop but just a supplementary variable to an interest income (IVb of Figure 2.1). Then, causal loop IVc of an bank balance growing is easily converted into a diagram D of Figure 2.1.

6.jpg

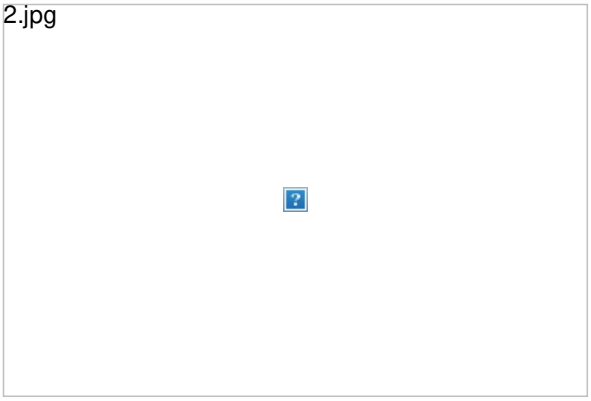


- **Characteristics**: In positive feedback, there is at least one Stock and one Flow with an arbitrary number of supplementary variables in a diagram as well as a causal loop.

2) As an example of negative feedback, let's think about a thing kept constant. At Step 1 this image can be converted as the goal seeking process or the Stock-Adjustment Process. In everyday speech this can be expressed as: "Setting a goal." or "Setting a goal for a thing." This is translated into causal loop I of Figure 2.2. Further this loop is refined into causal loop II by adding Difference, Goal and Action to Thing. This new loop II is recognized as causal loop III using Stock and Flow for the System Dynamics. In the case of thermostatic control, Stock is a temperature and Flow is an adjustment in causal loop IV. Then, causal loop IV of keeping a temperature at a goal is easily converted into a diagram D of Figure 2.2, in which Adjustment is translated as Bi-Flow.

- **Characteristics**: In negative feedback, there is at least one Stock, one Difference with one Goal, and one Bi-Flow in a diagram as well as a causal loop.

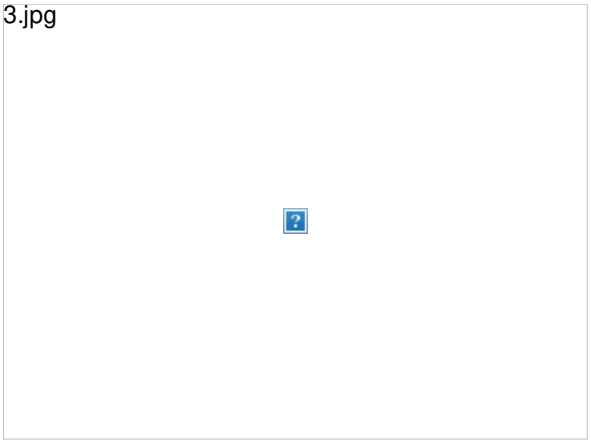
2.jpg



3) As an example of positive & negative feedback, let's think about a thing that grows and declines at will. At Step 1 this image can be converted as the limit to growth in a natural language: "As a thing grows there is a natural limit in which it stops developing." This is translated into causal loop I of Figure 2.3. This loop is refined into causal loop II by adding Action to Thing in positive feedback, and by adding Difference, Goal and Action to Thing in positive feedback. This new loop II is recognized as causal loop III using Stock and Flow for the System Dynamics. In the case of some condition, Stock is Condition in causal loop IV while Flow in positive feedback is Growing Action and Flow in negative loop is Slowing Action triggered by Difference from Limiting Condition. Then, causal loop IV of this condition controlled by the two feedback loops is easily converted into a diagram D of Figure 2.3 using the above two kinds of prototypes.

- **Characteristics**: In positive & negative feedback, there is one common element for two kinds of causal loops. In a diagram as well as a causal loop of the above case, in which the common element is Stock, there are the following aspects: one Difference with a Goal. and one Bi-Flow in positive feedback, and one Uni-Flow in negative feedback.

3.jpg



Conclusions

Three simple prototypes show that each causal loop has to be refined until the causal loop is clearly written using Stock and Flow. During this process an image about an event and an expression about it become explicit. So this process of Figure 1 is revised to a continuum of modeling process shown in Figure 3.

Through feedback at Step 2 in Figure 3 many kinds of variables will be added to causal loop. Characteristics of this kind of developing complex causal loop is necessary to be studied further for the aim of automating modeling processes.

4.jpg

References

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