CASE STUDY 1. Part 0: Engineering and Society

A Case Study for the DAAI Paradigm - Introduction
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Abstract

While the DAAI theory describes the general format of a theory dealing with engineering processes in general shall this text illustrate a possible case study applied to the phenomenon of cities, city-populations and their dynamics. The starting point is the 'bridge' between the DAAI paradigm in general and the focus on *simulation games* as the main method to enable DAAI like processes.

1 Actors as Occurring Encoding of Reality

The DAAI paradigm follows basically the route of Systems Engineering in describing that kind of processes which are leading from a problem and vision to some new and – hopefully – better solution. Departing from many texts in the field the DAAI paradigm gives the acting persons, here generally called *actors* – others like more the term *agents*[1] – a special emphasis: which kinds of actions have to be done or which kinds of documentation has to be written, as the main source for all this here the acting actors will be considered, the DAAI experts as well as the stakeholders triggering such a process. However these actors are *perceiving* their world, however their experience and knowledge *interprets* their perception, however their knowledge and their values *select* certain options of

[1] In general are all actors or agents or however you will name them *systems*, input output systems, with different kinds of behavior functions, making them *non-learning* or *learning* systems, *deterministic* or *non-deterministic*, *growing* or *not growing*, and so.

acting more than others, this will be decisive for the process which will *occur*. Clearly, this *guiding knowledge* is depending from the many different factors which have been *interacting* with such an expert *before* during his *learning processes*. In a certain sense one can speak of these learning processes inducing certain *cognitive structures inside* of the actor as an *encoding* of parts of the *real world*. For the actor itself are the cognitive structures the *experienced real* thing, while the triggering real world events are somehow *beyond* these induced cognitive structures, are *cognitively unreal* because not directly given.

2 Actors as Semiotics Systems

The encoding of parts of (empirical) reality does not represent the whole story. Generating some cognitive structures inside a biological organism functioning as *models of reality* for this biological system is a *pre-condition* for more complex processes. Another fundamental process is the *coordination of the behavior* of *different biological systems*. Because the different individual brains of the different systems have *no direct knowledge from each other* they have to organize *chains of events between* these brains which enable an *exchange* of *meaning*. While the *content* of meaning is rooted in the cognitive structures as such, the *chain of events* starting in one brain, changing states of the body, changing states of the environment, changing states of the receiving body until these physical states reach the other brain, these occurring changing events themselves are *not the meaning*![2] From the outset the *meaning* given in the generated cognitive structures and the different kinds of *physical chains of events* occurring during an interaction between different individual brains, they belong to *no natural relation*. They are quite *independent* from each other. A 'sound' is a sound and some 'neural ensemble' is some neural something. But from that moment onward when a brain starts some *mapping* between neural structures, which function as cognitive structures for the organism, and some possible chains of events, then the brain makes the physical events to *signs* by associating them with a *meaning* grounded in certain cognitive structures. This is the birth of what we have learned to call a *language*.[3] But, that one individual brain starts some mapping inside its own area is as such independent of possible mappings of other individual brains. Thus the ability of brains to start individual mapping processes in their 'private' areas is a pre-condition for the emergence of a certain language, but it is clearly not sufficient. There must an *additional mechanism* exist by which the different individual brains can *synchronize* their

[2]Remember all the many thousands of different languages in the world, which in some sense all speak about the 'same' world, the 'same' things, the 'same' events.

[3]There exists a whole bunch of scientific disciplines dealing with the different phenomena of languages. The most basic discipline is probably that what is called *semiotics* (cf. e.g. Noeth (1990)[N̈90])

individual mappings in a way that after some time every individual brain is realizing somehow the *same* mapping as the other brains. When this happens then a *language* is *emerging*.[4] In this context we assume that such language emerging processes are possible and that the acting actors in our examples have already learned a *common language* which is shared by all members of the team.

3 Teams Generating a Common World View

When we have acting actors whose individual brains have learned to transmit their encoded cognitive structures as meaning encoded in chains of events functioning as a language then arises the question how different actors can use the encoded meaning for a *common world view* which in a consequence can *guide* the participating actors in a *common way*?

Observable behavior: different individual brains are guiding the behavior of the individual body in a way that *different individual bodies* will meet at the *same time* at the *same location* to *interact* in a way, that after these interactions the *world has changed* in many different aspects only understood as *coherent* by the participating brains because they in their cognitive structures have set up a *cognitive coherence* which has been transformed by interactions into empirical world states. An example: to place a wastepaper basket somewhere besides a street does not make any sense as such. But if some actors *think* that they do not want that pedestrians throw their waste freely along the street and these actors assume that the presence of such a wastepaper basket can support a behavior to throw the waste into the basket, then the action of setting up such a wastepaper basket makes some *sense* in the brains of the acting actors ... and hopefully in the brains of the possible pedestrians too.

As this example can illustrate the *coherence* of real world things exists only in the *brains* of the *participating actors*. If a certain part of the possible pedestrians don't share the cognitive coherence of the causing actors then such a wastepaper basket does not work. Although such a wastepaper basket is physically present, it does not exist in the cognition of many pedestrians and therefore the behavior of these pedestrians is different compared to the behavior, the acting actors have intended.

Thus, talking about actors which are *citizens* of some city (town, metropolitan area,...) we can only assume that these citizens will *act in a similar way* if they share sufficiently similar cognitive structures functioning as their *world models*. From the outset of some planned common actions one can not nec-

[4] This process of the emergence of a language is subject of the meanwhile broad field of *language evolution*.

essarily assume that the participating actors share the same models. And even more one has to assume that every individual actor has no complete awareness about what he/ she/ x knows about a certain matter, because more than 99% of our experience and knowledge is *unconscious* and it only becomes *conscious* if the brain is triggered by some event which can *activate* some cognitive structures with some similarity to the triggering event.

Therefore, if we want that a certain group of citizens shall share a sufficiently similar model of a certain part of the city and that they want to act in a commonly shared way, then this group has to have the possibility to construct such a sufficiently similar model.

Because the number of possible aspects which can be important in the realm of a city can from the outset be very large, a group of citizens which want to share their models has to *agree on a small number* of those aspects which shall be used as the main trigger for the whole group.

During some period of time every citizen will *remember* different elements of the individual cognitive structures stored in the individual brain. Making these elements *visible* in some way (words, pictures, gestures,...) generates with these elements *new triggers* for itself and for the others. After some time most of the stored cognitive elements of the different brains which could be activated by these triggers will be *visible for all*. And usually is the set of all visibly remembered items *much larger* as the set which one actor would be able to remember alone.

Besides this, the set of all *visible remembered items* shows usually *no coherent structure*. A structure is given if a set of distinguishable *elements* can be associated with different kinds of *relations*. For instance are real objects usually embedded in some *space* and from this follow different kinds of *spatial* relations like *above*, *in front of* etc. Other kinds of relations are *legal* relations like *being the owner* of something, *being the son* of someone etc. Thus the *first findings* as the set of visible remembered items have to be enriched with all those relations which the participating citizens can *additionally remember*. The set of all these findings resulting in some *overall structure* can be viewed as a *set of facts* which all together represent a *state* of affairs to a certain point of time. If the different facts are depending from *different points of time* then one has to distinguish different states according to the time. One can also speak of a state as a *static model*.

As everybody can easily check our real world experience includes another fundamental relation which is very special: *change*. It is a basic everyday experience that *things can change*. Using some *artificial clock* one can detect an infinite variety of time scales for different kinds of changes: the universe shows

changes extending about billions of years, but there exist changes which are much faster consisting of very small fractions of a second.

Thus if one distinguishes between static states and changes leading from one state of affairs to another state where at least one fact has changed, then one can speak of a *sequence of states* which constitutes a process. In *reality* there exists only *one* process, that process which actually happens with a unique history. In the realm of *symbolic descriptions* one can play with different kinds of changes leading to *different sequences of states*.

If one combines a static model M with one set of facts with a set of possible changes X, then one can construct a *dynamic model* $\langle M, X \rangle$ which allows the description of highly complex processes.

If a group of citizens is able to transfer parts of their hidden individual cognitive structures triggered by a finite set of aspects into a visible set of items, can enrich this set by a set of relations getting a static model, and then can enrich the static model further by a set of possible changes, then this group of participants has set up a dynamic model as a *shared cognitive perspective*, as a *shared world view*, which enables these citizens to *act in the light of this common vision*.

4 Model Exploration by Gaming

As it is known by experience the human brain is very limited in the perception as well as understanding of all possible states of dynamic models. Thus the *elaboration* of a dynamic model is a comparable *simple* cognitive task compared to the *exploration* of a dynamic model. Besides the *cognitive limits* of the individual brain there is the dimension of the *degree of freedom* which is inherent in those actors who are causing a possible change. Thus a biological actor who in 99% of cases did decide for action A in context C can indeed change his decision at some point of time and can decide for action B. This single decision can – depending from the circumstances – trigger a cascade of other actions which finally change the course of events dramatically.

Another point of view is the self-experience of actors. To be *un-conscious* about oneself is not only valid for the cognitive aspects of our experience. Our different kinds of emotions being in some context are mostly unconscious too. Asking people by a questionnaire what they think what they would do in a certain verbally described situation will document opinions which in real cases with real behavior can diverge drastically. The *conscious self-picture* of people is *highly speculative* compared to the real dynamics of the body and the *mostly unconscious machinery of desires and emotions*.

Therefore the *whole story* of a *dynamic model* is usually not completely encoded in the dynamic model alone. The whole story is to a certain extend additionally encoded in the real actors, their *unconscious cognitive structures* as well as in their *unconscious emotional dynamics*. Therefor to understand the *whole* model requires that the group of citizens will *test* the dynamic model by *realizing the model* at least in the format of a *simulation game* which allows all participating citizens to act in the manner of the roles defined in the dynamic model but with the possibility to make use of the implicit degrees of freedom for every actor. Doing this the citizens can explore the possible cognitive aspects of the dynamic model as well they can explore the real behavior of themselves as well as of the others. This is an important part to understand whether and how the dynamic model can and will possibly work when applied to reality.

5 Evaluation and thereby Decoding a Model

While exploring a dynamic model in the format of a simulation game it is not recommended at the same time to try to evaluate the game. During exploration the main task is to enable a situation where every participant has the chance to act as if he/ seh/ x would act as in a real situation.

Because during such an exploration – usually called *testing* or *playing* or *gaming* or ... – many unforeseen new things can happen, many things in parallel, others distributed over different points of time, it is recommended to enable some *documentation* of the exploration process for an explicit evaluation afterwards.

Besides the *cognitive aspects* of the *observable process* as it occurred and what was the *final outcome* realized as final state of affairs, there is the *individual behavior* of each participant: implicit in the behavior different *decisions* have been made. What do these decisions reveal about the *motivations*, the different *interests*, the different *values*, the different *emotions* which possibly have influenced these decisions?

It can be helpful to make possible *differences* between *observable* behavior and *expected* behavior visible. This can be very important if these differences have been unknown to a citizen but at the same time are highly influential for what really happens. For a realistic forecast of possible states of affairs it is highly important that the probable behavior of people is clarified, although there exist enough other driving factors of a city process, which are often unknown in advance or difficult to control.

Very often does an evaluation reveal important aspects of the dynamic model, which are then candidates for posisble modifications.

6 Extending Engineering to Society: open processes with an open rationality

Hopefully these considerations so far can reveal the possibility how to extend the typical engineering process beyond the classical subjects of engineering into processes where citizens are involved as well as parts of the city itself. This points to an intriguing correspondence between *engineering and society*.

As Hsu and Nourbakshs (2020)[HN20] describe in their recent paper about *sustainable HCI* that the discipline of Human Computer Interaction [HCI]) has undergone a strong change because more and more topics of the society are now included in the subject of HCI because the design process not only determines the shape of a product or service in the narrow sense but can have and has strong influences of the society as a whole. Therefore it is necessary to include those parts of the society in the design process into the HCI analysis which will be receptive for these consequences.

As I have pointed out in my review of this paper[5] all this does hold for the DAAI paradigm too because DAAI is only a variant of HCI.

This overall correspondence between society – and therefore cities too! – and engineering is today often stated in the formula of *responsibility by design*. To that extend that engineering is touching overall aspects of the society it is necessary to include those parts of the society in the design process which will be touched by the consequences. For the classical topic of *urban planning* for instance radically new modes of planning have to be provided which indeed allow more responsibility represented by real parts of the citizens.

The above discussion reveals quite another aspect too. Society is usually characterized by being ordered by thousand, millions of different kinds of institutions which have defined procedures how to manage certain tasks in everyday life. A very famous book dealing with these institutional phenomena is that of Herbert A.Simon (1947 1st.ed.; 1997 4th ed.) [Sim47], [Sim97]). In a very extensive way Simon is analyzing the structure and behavior of administrations which determine the possible outcome. Compared to modern engineering which now is challenged by the society that the society, the citizens, are asking for

[5] cf. https://www.uffmm.org/wp-content/uploads/2019/06/review-Tsu-et-2020-acm-CommunitySciences.pdf

more real participation because they are mostly the affected persons of engineering, this kind of discussion is not yet as vivid for administrations as for common engineering.

Extending the methods of engineering to society with the inclusion of public processes of model generation, model exploration and model evaluation highly probable will be able to improve the interaction between engineering and society as well as between the society itself and its citizens!

As the example of classical engineering and classical administrative behavior show it is necessary to *open* the so far closed processes in a dynamic and sustainable way. This enabling of *open processes* does not diminish rationality but – on the contrary – at the first time introduces an *open rationality* which is – as it appears – the only format to enable rationality within a world of open processes.

7 Democracy as Political Shape of Open Rationality

The topic *Democracy* and *open rationality* is a too big point to be discussed here sufficiently well. But at least I want to mention that the political format of a *modern democracy* is a 'derivative' of this concept of an open rationality within open design processes. Therefore it could be an interesting challenge to reconstruct the actual democracies in the light of these two terms.[6].

References

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[Sim97] Herbert A. Simon. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization*. The Free Press, 4 edition, 1997.

[6] A very interesting scientific position whose discussion in this context could be exciting is the position of the sociologist and systems thinker Niklas Luhmann (cf. `https://en.wikipedia.org/wiki/Niklas_Luhmann`