ACTOR-ACTOR INTERACTION
Philosophy of the Actor

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Email: info@uffmm.org

Gerd Doeben-Henisch
Email: gerd@doeben-henisch.de
Frankfurt University of Applied Sciences (FRA-UAS)
Institut for New Media (INM, Frankfurt)

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Abstract

As preparation for this text one should read the chapter about the basic layout of an *Actor-Actor analysis (AAA)* as part of an *systems engineering process (SEP)*. In this text it will be described which *internal conditions* one has to assume for an actor who uses a language to talk about his observations of the world to someone else in a verifiable way. Topics which are explained in this text are e.g. 'language', 'meaning', 'ontology', 'consciousness', 'true utterance', 'synonymous expression.

I. A Vision as a Problem to be Solved

In this world many different problems can be identified or can be considered as interesting cases. In this text we assume the following vision as a possible problem which should be solved: *set up interactive computational environments which allow the stepwise development of more and more intelligent machines, which help human actors to do their job better.*

Within this global vision a *core-idea* is the assumption of *actors* living in an *environment*, where one can set up multiple forms of *experiments* to test the potential for *learning*, becoming/ being *intelligent*, and becoming helpful.

To *translate this vision* into a concrete working program can be done in *many different ways*. To select one possible path in this nearly infinite space of conceptual frameworks and languages is not trivial. There is in advance no *best* path. From history of ideas one can get lots of proposals what had worked out until now with which results, but even in the light of the history there are many options, not only one.

This text is a kind of a *conceptual experiment* trying to bring together at least three different languages within the *actor-actor interaction (AAI) paradigm* as part of a *systems engineering process*: (i) a description with *natural language* L_0; (ii) a description with a *mathematical language* L_ϵ; and (iii) a description with a *programming language* $L_{python3}$. Clearly there are much more languages available, but this text confines itself to these three.

Due to the AAI paradigm it is assumed that there are *AAI experts* which will do the job of describing the problem with these mentioned three languages as *observers* which are understood as *actors*.

II. Language, Meaning & Ontology

A. Language Levels

The challenging point is that the AAI experts, when they are using these three different languages, are assumed to talk in each case always about *the same subject matter*. Thus we assume here that a first text D_{L0} written in some natural language L_0 gives a first outline of this presupposed subject matter $DAT_{0,i}$ as being observable by a *normal observer* $o_i \in OBS_0$.[1] Then there will be a second text D_ϵ written in a mathematical language L_ϵ. This second text shall be a 'translation' from the first text into the second mathematical text. Although the used expressions may look differently, they should communicate the same subject matter. Finally we assume a third text $D_{python3}$ written in a programming language $L_{python3}$ which is again a 'translation' from the second into the third programming text.

$$articulate_{o,i} : DAT_{0,i} \times L_0 \longmapsto D_0 \quad (1)$$
$$translate0_{o,i} : DAT_{0,i} \times D_0 \times L_\epsilon \longmapsto D_\epsilon \quad (2)$$
$$translate\epsilon_{o,i} : DAT_{0,i} \times D_\epsilon \times L_{python3} \longmapsto D_{python3} \quad (3)$$

B. Common Empirical Matter

As one can see from this description an epistemological problem arises with the assumption of a *presupposed subject matter* DAT_0. All the texts are assumed to be 'descriptions' of this subject matter but the *subject matter* as such *is not a text*! The subject matter 'exists' only as a *stream of perceptions* for a certain observer o_i. Therefore a normal observer' having perceptions uses some language L_0 to *talk about* his personal perceptions $DAT_{0,i}$.

'How' the observer will 'talk about' his perceptions depends from the *manner, how he has learned to use the language* L_0.

The other point is that a language as such is an *interpersonal* pattern to allow a *minimal coordination* between the *language usage* of *different observers*. To make this idea acceptable one needs the assumption, that there exists some *common experience* MAT which is *common to all observers*. It is assumed here that actors have a *body* which occurs in a *real world (RW)* which is common for all bodies. To focus on that part of a real world which is 'close' to every body the term *situation (SIT)* is

[1]There is no general definition of a 'normal' observer. A very broad assumption could be that a 'normal' observer is a person which has no 'handicaps' in the light of some medical standard.

used. Situations are those parts of the real world which can simultaneously be observed from different actors in approximately the 'same way'. For an observable part of the world SIT it is assumed that it can *stimulate* σ an actor in a way that the assumed *external sensors of the actor* can be triggered. This triggering of the external sensors induces some *perceptual content* $DAT_{0,ext.sens}$ in the input of an actor.

$$\sigma \quad : \quad SIT \longmapsto ACT \tag{4}$$

$$s \in SIT \wedge \sigma(s) = \alpha \quad \Rightarrow \quad DAT_{0,ext.sensors} \subseteq INP_{\alpha} \tag{5}$$

Such a common cause external to all participating observers is here called an *empirical matter* MAT. Thus if the individual sensory perceptions $DAT_{0,i}$ of every participating observer i are *sufficiently similar* and as well the manner how each observer *uses* his language L_0, then all the participating observers can produce individual descriptions $D_{0,i}$ which all are sufficiently the 'same'.

One has to mention that human bodies have another 'external' source of perceptions which stem from the *inner of the body* by *proprioceptive sensors*. These too can be triggered by an external stimulation (e.g. the feeling of 'balance' depending from the position of the body in the real world). Thus one had to write:

$$s \in SIT \wedge \sigma(s) = \alpha \quad \Rightarrow \quad (1) \wedge (2) \tag{6}$$

$$(1) \quad DAT_{0,ext.sensors} \subseteq INP_{\alpha} \tag{7}$$

$$(2) \quad DAT_{0,propr.sensors} \subseteq INP_{\alpha} \tag{8}$$

There can be even more perceptions from the inside of the body which are not triggered by an outside stimulation. Let us call these kinds of perceptions *body intrinsic perceptions* $DAT_{0,intrinsic} \subseteq INP_{\alpha}$. Thus, we get:

$$DAT_0 \quad = \quad DAT_{0,ext.sensors} \cup DAT_{0,propr.sensors} \cup DAT_{0,intrinsic} \tag{9}$$

C. Perceptual Levels

This picture so far is not yet complete. As modern *Psychology* can demonstrate the normal human observer does not use his perceptions DAT_0 directly but translates the perceptual experience DAT_0 in an automatic way in *more abstract structures* DAT_1 which are enabled by some general abstracting mechanisms of the *memory* mem:

$$mem \quad = \quad generate0 \otimes generate1 \otimes activate \otimes associate \tag{10}$$

$$generate0 \quad : \quad 2^{DAT_0} \longmapsto DAT_1 \tag{11}$$

$$generate1 \quad : \quad 2^{DAT_0} \times DAT_1^n \longmapsto DAT_1 \tag{12}$$

$$activate \quad : \quad 2^{DAT_0} \times DAT_1 \longmapsto DAT_1^{act} \tag{13}$$

$$associate \quad : \quad DAT_1^{act} \longmapsto DAT_1^{ass} \tag{14}$$

This means that the concrete elements of the sensory perception DAT_0 will automatically be transformed from the memory mem into abstract *classes* either as a new class with *generate0* if there does not yet exists a class which can *match* the new input or as *belonging* to a given class with *generate1*. The set of abstract classes is called DAT_1. Every concrete perception $p \in DAT_0$ which belongs to a class is called an *instance* of this class.

Furthermore the actual content of the perceptions DAT_0 *activates* a finite set of classes DAT_1^{act} which in turn activate a finite set of *associated* classes DAT_1^{ass}.

All these elements together – actual perceptions DAT_0 as well as activated and associated classes $DAT_1^{act} \cup DAT_1^{ass}$ – will be part of the *consciousness (CONSC)* of an actor. One can also say that the consciousness defines a primary *ontology* DAT_{ontol} of the actor, this is the basic set of entities which are reachable for an actor.

$$CONSC = DAT_0 \cup DAT_1^{act} \cup DAT_1^{ass} \quad (15)$$

$$DAT_{ontol} = CONSC \quad (16)$$

D. Space & Time

When human actors perceive sensory data from the real world then these data are automatically organized as perceptions in a *2-dimensional space* R^2 which can further be mapped into a *3-dimensional space* R^3. This holds also for all classes which are generated on the basis of these perceptions. Therefore all the classes with their instances are associated to partial spaces which allow the construction of *spatial relations* for these elements in space. This spatial structure can also be associated with the the ontology and the consciousness.

Similar allows the memory to distinguish between *actual* perceptions and *past* perceptions which are often called 'memories'. Therefore it is possible to organize all elements of an ontology as elements of a *temporal ordering* with *(a before b)* $a < b$. In this way one can construct *successions* of whole situations allowing the detection of certain *patterns* with *frequencies* as well as *causal relations*.

E. Different Language Modes

Until now the used language L was not differentiated further. But what happens to the language if we distinguish between the real world matter MAT, the sensory perceptions DAT_0, and the abstracted classes DAT_1?

Clearly the language is not independent from these different *modes of existence*. Language too occurs as an empirical matter $L^m \subseteq MAT$ in the real world, if someone *utters* an expression; such a real world occurrence L^m can stimulate a sensory experience of the language expression $L^0 \subseteq DAT_0$, which in turn generates certain classes $L^1 \subseteq DAT_1$.

F. Meaning of Expressions & Ontology

If one has an real world expression e^m of a language L one is often talking about the *meaning* μ of such an expression. In the context of this text the meaning of expressions from the language L_0 has to be related to the ontology DAT_{ontol} of the actor. Then one can define the meaning of the language L_0 as the image of the mapping from language expressions into the ontology. But here it is important to look to the different language modes.

An expression occurs usually as an real world expression e^m, but 'behind' this real world expression there exists a sensory mode e^0 as well as an abstract mode e^1. In this text it is assumed that the meaning relation is realized between the abstract mode of the language and the ontology:

$$\mu \quad : \quad L^1 \longmapsto DAT_{ontol} \tag{17}$$

Within this framework it is possible that a language expression e^1 as automatic part of the ontology DAT_{ontol} can be part of the used language as well as part of the subject matter. In this manner a language can talk about itself.

G. True Expressions

As one can infer from the preceding assumptions one can generate an expression e^1 which has some meaning $\mu(e^1)$, but from the meaning as such it does not necessarily follow that there 'exists in the real world' a 'matter' m whose stimulation $\sigma(m)$ would 'match' the meaning as $\sigma(m) =_{match} \mu(e^1)$.

Thus the case of *matching* between some language-bound meaning and a real-world stimulation is a special case which deserves it's own name. We will say, that an expression e^1 uttered by some observer A as e^m is told to be *true* if there exists a real world matter m as part of the uttering situation SIT and the stimulated representation $\sigma(m)$ matches the presupposed meaning $\mu(e^1)$.[2]

One can define this as a simple *language game for an empirical truth verification procedure* as follows (assuming an actor A doing this):

$$utter = e^m \in SIT \tag{18}$$

$$point = m \in SIT \tag{19}$$

$$\sigma(m) = \mu(e^1) \tag{20}$$

$$confirm = yes \tag{21}$$

This language game works for a single actor A. Only he can know whether the real world occurrences of m and e^m indeed 'match' some internal meaning correlated with this expressions. Therefore is the concept of 'matching' in this context not clearly defined; the *consciousness* of the actor represents a reference which is not publicly accessible.

To overcome this fuzziness and uncertainty in the usage of expressions one has to go one step further and one has to consider the case of *synonymous expressions between two different actors*.

H. The Congruence of Meaning

Let us assume that an actor A utters an *expression* e^m in a situation SIT which he confirms to be *true* with regard to some real-world matter $m \in SIT$. Another actor B would use the expression e^m in a congruent way if actor B would also *confirm* the trueness of expression e^m with regard to m because the stimulation $\sigma(m)$ in his perceptions yields a perception in his consciousness which matches the meaning $\mu(e^1)$ which actor B associates with the expression e^m.

Again one can define a simple *language game for an empirical verification of the congruence of meaning* as follows (assuming two actors A and doing this):

[2]This concept of a true utterance agrees substantially with the definition of Tarski (1938) [Tar38]

$$utter_A = e^m_A \in SIT \tag{22}$$
$$point_A = m \in SIT \tag{23}$$
$$confirm_A = yes \tag{24}$$
$$\sigma_B(m) = \mu_B(e^1) \tag{25}$$
$$confirm_B = yes \tag{26}$$

Although both actors can not inspect the internal matching of the other actor they can agree in the usage of an expression e^m in a shared situation SIT where also a real world matter m occurs.

III. Actor Algebra

In this section all the different properties of actors mentioned before shall be integrated into one coherent *actor algebra (AA)*. In a next step then the actor algebra will be inserted in a more global *world algebra (AW)*.

$$AA(x) \quad iff \quad x = \langle INP, OUTP, DAT_0, DAT_1, L^0, L^1, DAT_{ontol}, CONSC, mem, \mu, \phi_{int}\rangle \tag{27}$$
$$INP := Perceptual\ input \tag{28}$$
$$DAT_0 = INP \tag{29}$$
$$DAT_0 := Stimulated\ perceptions \tag{30}$$
$$DAT_0 = DAT_{0,ext.sensors} \cup DAT_{0,propr.sensors} \cup DAT_{0,intrinsic} \tag{31}$$
$$DAT_1 := Abstractions \tag{32}$$
$$L^0 \subseteq DAT_0 \tag{33}$$
$$L^1 \subseteq DAT_1 \tag{34}$$
$$mem = generate0 \otimes generate1 \otimes activate \otimes associate \tag{35}$$
$$generate0 : 2^{DAT_0} \longmapsto DAT_1 \tag{36}$$
$$generate1 : 2^{DAT_0} \times DAT_1^n \longmapsto DAT_1 \tag{37}$$
$$activate : 2^{DAT_0} \times DAT_1 \longmapsto DAT_1^{act} \tag{38}$$
$$associate : DAT_1^{act} \longmapsto DAT_1^{ass} \tag{39}$$
$$CONSC \supseteq DAT_0 \cup DAT_1^{act} \cup DAT_1^{ass} \tag{40}$$
$$DAT_{ontol} = CONSC \tag{41}$$
$$\mu : L^1 \longmapsto DAT_{ontol} \tag{42}$$
$$OUTP := Output\ to\ the\ world \tag{43}$$
$$\phi_{int} = utter \cup point \cup confirm \tag{44}$$
$$utter : L^1 \longmapsto OUTP \tag{45}$$
$$point : DAT_{ontol} \longmapsto OUTP \tag{46}$$
$$confirm : L^1 \times DAT_{ontol} \longmapsto OUTP \tag{47}$$

Thus an actor algebra describes a structure which hast an input (INP) for sensory data and an output (OUTP) for effects onto the world. The sensory input stems from at least three different sources: from the outside (assumed) real world as $DAT_{0,ext.sensors}$, from the inside but triggered from the outside as $DAT_{0,propr.sensors}$, and finally only from the inside as $DAT_{0,intrinsic}$. The used languages share these different modes written as L^0, L^1. The memory structure which can store perceptions is a highly dynamic system, which automatically translates perceptions into more abstract structures and manages these structures continuously.

In this text it is assumed that the *memory* works like a big function which has at least four sub-functions. This are the functions *generate0*, *generate1*, *activate*, and *associate*.

The function *generate0* maps automatically arbitrary kinds ob subsets of the sensory data 2^{DAT_0} into more abstract structures DAT_1 from scratch. The function *generate1* does the same but this function can combine perceptual structures and different existing classes $2^{DAT_0} \times DAT_1^n$ into more complex classes DAT_1. The sub-function *activate* activates abstract structures in the memory DAT_1^{act} triggered by actual perceptions and their relations to abstract structures $2^{DAT_0} \times DAT_1$. Finally the sub-function *associate* activates also those abstract structures DAT_1^{ass}, which are in some way associated with the already activated abstract structures DAT_1^{act}

The set of perceptions 2^{DAT_0} as well as the abstract structures activated DAT_1^{act} as well as associated DAT_1^{ass} with activated structures are all subsets of the *consciousness (CONSC)* of an actor. The consciousness is also the basis for the *ontology* of the actor DAT_{ontol}.

Therefore the *meaning* μ of a language is here assumed to be a mapping between the abstract mode of the language as well as the content of the consciousness.

Whatever shall be outputted in a certain situation SIT from the actor to the real world has o be mapped to this output $OUTP$. As possible *internal* actions preparing some output there are the functions *utter, point*and *confirm*. . As assumed before the actors do not occur isolated but as part of a bigger real world.

IV. World Algebra

Here a proposal for a first version of a *World Algebra (WA)* embracing all necessary factors.

$$
\begin{aligned}
WA(x) \quad & iff \quad x = \langle MAT, ACTR, R^3, \lambda, \epsilon, \sigma, \phi \rangle && (48)\\
MAT \quad & := \quad Empirical\ Matter && (49)\\
ACTR \quad & := \quad Actors && (50)\\
ACTR \quad & \subseteq \quad MAT && (51)\\
R^3 \quad & := \quad Set\ of\ 3-dimensional\ coordinates && (52)\\
\lambda \quad & : \quad MAT \longleftrightarrow R^3 && (53)\\
\epsilon \quad & : \quad MAT \longmapsto MAT && (54)\\
\sigma \quad & \subseteq \quad \epsilon && (55)\\
\sigma \quad & : \quad MAT \times ACTR \longmapsto ACTR && (56)
\end{aligned}
$$

A world algebra (WA) includes empirical matter (MAT), a set of actors (ACTR), a set of 3-dimensional coordinates R^3, a change function ϵ to change the empirical matters, a stimulus function σ to stimulate the perceptions of an actor by empirical matters, as well as a behavior function ϕ of an actor to induce some change onto the empirical matter (including the actor itself).

To connect the world algebra with the actor algebra one has to introduce two *mapping axioms (AX1, AX2)* as follows:

$$
\begin{aligned}
AX1 \quad &: && (57)\\
s \in SIT \wedge \sigma(s) = \alpha \quad &\Rightarrow \quad (1) \wedge (2) && (58)\\
&(1) \quad DAT^{\alpha}_{0,ext.sensors} \subseteq INP_{\alpha}\\
&(2) \quad DAT^{\alpha}_{0,propr.sensors} \subseteq INP_{\alpha}\\
AX2 \quad &:\\
s \in SIT \wedge \sigma(s) = \alpha \quad &\Rightarrow \quad \epsilon(OUTP)^{\alpha} \subseteq MAT
\end{aligned}
$$

V. How to continue

These first outlines of possible world and observer algebras are still very general. To use these concepts in real applications, one has to look to real cases with real languages and show with these examples, what has additionally to be included in the definitions.

References

[Tar38] A. Tarski. Grundlegung der wissenschaftlichen Semantik. *Actes du Congrès de Philosophie Scientifique*, III, ASI 390:1–8, 1938.