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Robotic Society – Main Features For Base Design of Human-similar AI Robots

Jochen Mau

Heinrich Heine University Düsseldorf, School of Medicine, 40225 Düsseldorf, Germany (e-mail: ismmau@hhu.de).

Abstract: In the design process of cognitive human-machine systems, focus is on novel engineered components while the human component is generally considered as known, at least at large: as the cognitive ability of a person expresses in communication, verbal and behavioral, within his or her life–sphere surroundings, whether kindergarten, school, neighborhood, work place, leisure activities, or elderly home, its characteristics are persistent patterns that emerge with biological and cognitive development during childhood and adolescence, are shaped by social interaction in adult life, and finally modified by shrinking vitality in biological aging. However, such phenomenalistic categorization is certainly inadequate as communication is actually an expression of in–system functional dynamics and their controls. It is then their high degree of interweavement across several scale levels, that also interlaces the controls of reproductive subsystems with all other functional subsystems within the human body and thus mandates a fundamental distinction between male and female cognition beyond pregnancy and maternity. As the structure of physiological couplings of functional dynamics within the human body is not understood, impact from outside on within-dynamics is analytically unforeseeable for the machine component. A recent axiomatic theory of multi–scale holistic functional biodynamics for human–body system suggests a concept for functionally equivalent virtual machines, "human–similar AI robots", that "live" through a human life–cycle from childhood to old age, as appropriate for each sex. Connected to it is an understanding of human social life's driving forces as anxiety about loosing (access to) life resources.

Keywords: holistic view ; functional body-system ; axiomatic biodynamics ; sociocybernetics

1. INTRODUCTION

Cognitive human-machine systems have their application in cooperation for extremely challenging task-solving when the task surpasses human possibilities, and also for enhancement of a person's possibilities when limitation rests in the person. The latter context will be used for motivation, theoretical interest and wider applicability notwithstanding. Quite generally, robot assistance to humans will be more effective due to a higher acceptancy when an assisting robot appears similar to the assisted human in communication, both verbal and behavioral. Consequently, it will not be a good idea to develop one comprehensive robot assistant for all purposes as the targeted human population consists of distinct subpopulations with distinct specific assistance needs: the most obvious are the two sexes of males and females within three age groups according to biological maturation and cognitive formation – childhood and adolescence, adult life in social interaction subject to societal framing, and modification of skills and potentials by a shrinking vitality in biological aging. A few illustrations will be helpful.

- Nobody wants to be together with a "knows-all", whether person or robot; the master in the robot may even be more intimidating than the master in a person, as one generally knows that every person can fail; a robot then appears as super-natural in skills and power.
- As the differences between sexes naturally dominate human perception of behavioral communication, any "lady robot" must be familiar with all lady topics, issues, and problems, while a "gent robot" will be familiar with gent topics, issues, and problems, and will best seem to know little about the other kind of robot in order to be authentically 'gent'.
- "Adult robots" will not understand human-child problems from a child's perspective without having experienced progression through life's early ages, not to mention the specific boys and girls problems.
- Learning with an "adult robot" in class is less motivating than learning with a "classmate robot" that is also still learning, has knowledge deficits and can then better understand and better address the problems of human learning difficulties, or may even be more effective in teaching a subject.
- An "old-age robot" will understand the anxiety of old persons to loose competence in access to vital resources.

Current research investigates person's behavioral patterns for statistical correlations with measurable parameters of physiology, mood, and cognitive functions; see [Wang and Pan (2016)] for many examples of research from this phenomenalistic viewpoint by which human behavior, cognitive ability to control operations and making decisions on options, economic or other, is associated with patterns of brain activity in experimental set-ups, see [Mau (2017)] for a brief specific overview. That enacted operational decisions which generate a person's behavior must be seen as outcome of his or her physio-functional *Whole*, is not new information [Varela et al. (1991)], but also not sufficiently compelling to imply a change of paradigm. The simple observation that human brain just cannot work independently of whole-body physiology motivated a stringent holistic perspective about whole human-body system from a systems engineering viewpoint, more recently.[Mau (2016d, 2018a)]

The reason for this shift of focus rests in two observations: a person's biological body is an intrinsically dynamic living system and as such tuned to fit nature's primary design motif, *survival to reproduce*, and any person's life can only evolve within a habitual environment and a social context, occasional variation notwithstanding.

By the prevailing reductionism in medicine which is certainly inevitable as long as the human body's highly complex functional structure and interactive dynamics with meshed controls from cell to whole are not completely understood, only "knowledge pieces" can be expected, and their coherent integration would still require a holistic systems understanding, first. Therefore, instead of virtually re-engineering a complete functional body system from its parts as pursued in the Physiome Project [Bassingthwaighte (2000)], a holistic mathematical construction of functionally equivalent virtual body systems would be a more promising way to go. Such *artefactual body system of human-similar (physiological) functionality* should be used like a 'dummy' instead of training and testing on a living system; definition of its functional dynamics across all scale levels can be based on a recent mathematical theory of effectuation dynamics for a single functionally hierarchical system [Mau (2018b)].

An artefactual human-body system that is able to *virtually experience* the basic features of a real person's body system dynamics of physiological functions – specifically, breathing, ingestion and digestion of nutrients with egestion of residuals, wake-sleep rhythms for daily restoration, energy storage in resting and energy consumption in labor of all subsystems – shall be called a *human-similar robot*, irrespective of possible encasement for human-similar appearance. When invested with an AI-"mind" for cognitive task-solving, it is called a *human-similar AI robot* and shall then be able to *virtually mimic* verbal and behavioral communication with others, real human persons, in particular, and human-similar machines, with or without an AI-"mind", too.

When the machine component of cognitive human-machine systems is then able to interprete the human component's communication from AI insight into the other's physio-functional dynamics, it still lacks background about base principles according to which social interaction among humans occurs, with respect to sex and age, in a given context of culture, ethics, rules, and laws – the *societal framing*, for short. Discussion of a 'robotic society' means an exploration of the core forces that drive main dynamics of person's social interaction with others; to remove variant human detail as much as possible, the adopted level of abstraction will reduce a person to a *human-similar AI robot*. The purpose is then not the study of coordinated use of robots in industrial fabrication, but the control of social dynamics in a conglomeration of individual human-similar machines: *sociocybernetics*, with reference to the Greek, or *social governance*, with reference to the Latin language.

First, a recently proposed axiomatic approach will be used for a holistic perspective on functional human-body system (Section 2), and then features of social interaction will be worked out from few base principles about human nature (Section 3). Mathematical theory is relegated to an appendix.

2. THE SETTING FOR A SINGLE SYSTEM

2.1 Canonical Decomposition

The basic tenet is that every system *made for a purpose*, whether engineered or natural living, can be functionally decomposed into three level-1 *logical units*, a unit that energizes the other two, another unit that performs the physical tasks, and finally a unit that operates the tools of the former; an intuitive example could be an excavator with a human or a *human-similar AI robot* as operator, though these are powered separately from the excavator machinery.

The following condensed description from [Mau (2017)] for a human-body system introduces the concept more specifically with some notation: denote human body system by $\mathcal{H}$, and its physical body *bio-sphere* by $\mathcal{B}(\mathcal{H})$, its *eco-sphere* of natural or man-made habitual environment by $\mathcal{E}(\mathcal{H})$, and the person's *socio-sphere* of economic opportunities and social embedding by $\mathcal{S}(\mathcal{H})$; then $\mathcal{B}(\mathcal{H}) \supseteq \mathcal{H}$, and the three spheres together span the person's *life sphere*, $\mathcal{L}(\mathcal{H})$, say, and $\mathcal{L}(\mathcal{H}) = (\mathcal{B}(\mathcal{H}), \mathcal{E}(\mathcal{H}), \mathcal{O}(\mathcal{H}))$. $\mathcal{L}(\mathcal{H})$ sets the frame to all personal operational decisions and their enacting, in other words to the person's (actual) operations – perceived and denominated as *behavior* – in his or her life sphere surroundings $\mathcal{E}(\mathcal{H}) \cap \mathcal{S}(\mathcal{H})$ of person's eco-sphere $\mathcal{E}(\mathcal{H})$ and person's socio-sphere $\mathcal{S}(\mathcal{H})$, that form the "outside world" of $\mathcal{H}$.

The source of human body system $\mathcal{H}$'s operations is then located in its bio-sphere $\mathcal{B}(\mathcal{H})$, from where operations arise through coordination of three functional groups in human body bio-system $\mathcal{B}(\mathcal{H})$,[Mau (2016d)]

- a (sub-)system of vital body functions, $\mathcal{V}$,
- a (sub-)system of (re-)production functions, $\mathcal{P}$,
- a (sub-)system of operational functions, $\mathcal{O}$.

Then, $\mathcal{B}(\mathcal{H}) = (\mathcal{V}, \mathcal{P}, \mathcal{O}, \mathcal{Z})$. Denote human body's cellular system by $\mathcal{Z}$, and take it as the *material component* of $\mathcal{B}(\mathcal{H})$; the study of $\mathcal{Z}$ aims to understand the "pure mechanics" of human body system's functioning.

In application of said *kybernetic paradigm*, functional modeling considers only $\{\mathcal{H}|\mathcal{Z}\}$. The functional model of $\{\mathcal{H}|\mathcal{Z}\}$ adopted from [Mau (2016a)] is a built-up of hierarchically nested *functional levels*, FL, each composed of *functional units* that represent some specific functionality within their level.

From such viewpoint, a person's physical operations are $\mathcal{P}$-enacted, but emerge from interaction of all three functional groups, symbolically (with $\times$ to represent interaction)

$$\{\mathcal{H}|\mathcal{Z}\}\text{–operations} \leftarrow \{\mathcal{V}|\mathcal{Z}\} \times \{\mathcal{P}|\mathcal{Z}\} \times \{\mathcal{O}|\mathcal{Z}\}. \quad (1)$$

Such "creative interaction" may be *intrinsically* or *extrinsically* motivated, in pursuit of $\mathcal{B}(\mathcal{H})$-internal "needs and desires", the *driving forces*, or in response to "signals" from $\mathcal{E}(\mathcal{H}) \cap \mathcal{S}(\mathcal{H})$ as *impact* from person's life-sphere surroundings, respectively.

Note 1: $\mathcal{H}$ refers to the person, $\mathcal{B}(\mathcal{H})$ to biological body.
Note 2: Locating the source of operations in $\mathcal{B}(\mathcal{H})$ is to pass by the problem of *"where does mind end and where does environment begin?"*. [Clark and Chalmers (1998)]
Note 3: (Re-)production encompasses physical production and sexual reproduction, but not purely mental production.
Note 4: Enacted anatomically, this means enacted by the body's musculo-skeletal and sexual-reproductive subsystems.
Note 5: Individual properties of each functional group are implicit in their interaction.

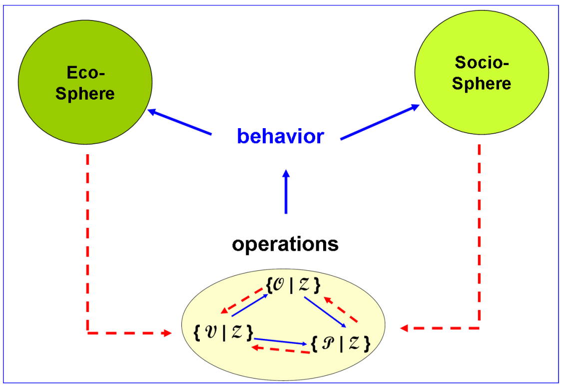

Fig. 1. *A person's operational activity as an emergent expression of interaction between human-body system's three canonical wirk-components of person's vital, productive and operational functions is perceived as behavior by his or her life-sphere surroundings.*

2.2 System Functional Architecture

Basically, a person is in permanent interaction with his or her life-sphere surroundings. With cognitive communication, verbal or behavioral, driven by person's operational objectives, response from body's outside world may not only modify objectives but will also give rise to rebound effects on body system's physiological dynamics.[Clark and Chalmers (1998)] Stress syndromes, burn-outs, and nervous break-downs stand for some widely known examples that are among what a *human-similar AI robot* must be able to experience within its own *artefactual body system*, then. A formal structure is briefly described next.

The concept of a holistic systems view [Mau (2017)] is based on a separation of organization from material in analysis of complex systems; the underlying idea that principles of an organizational science can be invoked to explain emergent properties irrespective of their physical realization, is implicit in [Sachsse (1974)] and has been highlighted as the *kybernetic paradigm* [Mau (2016a,b,c,d)]. (The word *kybernetik* is closer to the original Greek, refers to Wiener-sense *cybernetics* [Wiener (1961, 1963)], and must not be confused with its modern digital interpretation of the anglisised word.)

The motivation for a *drill-down* approach in functional analysis of complex systems arose from the common observation, that behavior of the whole emerges from activity of functional components and coordination of their interaction, as illustrated in Fig.1. In Fig.2, *logical units* (LU) are shown as boxes that combine to *logical aggregates* (LA) visualized in the horizontal bars – which then appear as the *logical units* (LU) of the next upper functional level; the top five *functional levels* (FL) are shown, with the functional *Whole*, denoted by $\{\mathcal{B}|\mathcal{Z}\}$ as FL0, its three canonical *wirk*-components of energy-supplying vital functions, $\{\mathcal{V}|\mathcal{Z}\}$, physical production functions $\{\mathcal{P}|\mathcal{Z}\}$, and operational (piloting) functions $\{\mathcal{O}|\mathcal{Z}\}$, at FL1, and further successive schematic decomposition into unspecified logical units at FL2, FL3 and FL4, cf. [Mau (2019b)] for a more detailed description. As a holistic functional

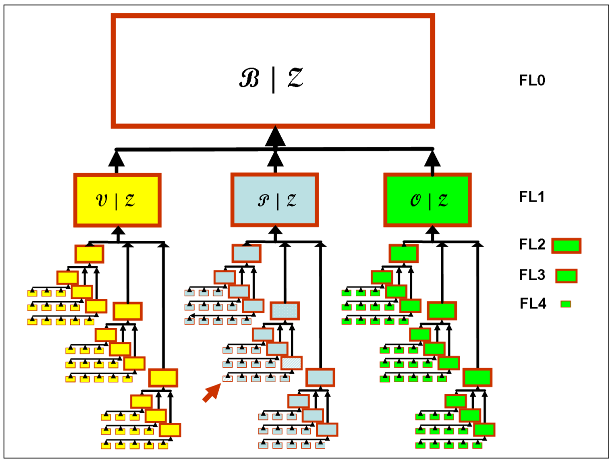

Fig. 2. *Organigram-style representation of the strictly hierarchical structure for effectuation dynamics in System Functional Architecture (SFA).[Mau (2019b)]*

structure of human body-system dynamics and person's behavior [Mau (2016c,d)], one has to add a theoretical framework according to which a consistently scaled power system can energize scaled activity in terms of first-order differential equations [Mau (2018b)]: the key issue would be a coherent up-scaling such that upper level dynamics "emerge" from lower level dynamics.

2.3 Axiomatic Functional Biodynamics

The construct The purely theoretical formulation of a *configuration of effectuation dynamics* independent of physical realization, referred to as an *axiomatic "wirk-gefüge"*, uses the "thought model" of a generic twin-circuit as shown in Fig.3 to first energize each *logical unit* – the boxes in Fig.2 – within a *logical aggregate* and then translates to next upper aggregate-level dynamics in "up-scaling". First-order dynamics within a generic *pseudo-electric* twin-circuit are described in terms of "source", "resistors", "condensers (capacitators)" and "end-consumer's power demand", borrowed terms chosen just for their intuitive meaning and without any suggestion that physical electricity might be involved.[Mau (2018b)]; see Appendix A for mathematical details.

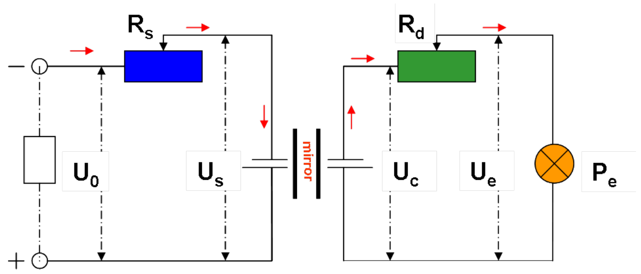

Fig. 3. *Illustration of concept for dynamics in a single functional unit: generic pseudo-electric twin-circuit according to [Mau (2018b) Fig.1] as a pair of electric circuits for supply (left) and demand (right). Voltages U – from left to right – denote source, effective supply voltage at condensor after voltage drop according to resistance R_s, voltage at demand-part condenser generated by prevalent charge, and effective voltage at end-consumer after voltage drop according to resistance R_d, respectively; P_e denotes end-consumer's power demand.*

Identification To apply this axiomatic theory to real-world phenomena, one then needs an "interfacing construct", a theoretical concept for the real-life phenomenon under study, called the *identification model* and still another model, an *estimation model* that connects the identification model to observations made of the real-life phenomenon; these observations are obtained as *the data*. A last step will typically involve a *statistical-analysis model* according to chosen analysis objectives, e.g. estimation, hypothesis testing or regression analysis in adjustment for heterogeneity.

These procedures are significantly simplified by a rephrasing in terms of *intensity functions* as theoretical construct that can be obtained easily from the first-order differential equations that were introduced in [Mau (2018b)] and be shown to characterize these dynamics, cf. [Mau (2019b)]. The intensity-function approach lends itself more easily to identification and implies an estimation model that is appropriate in many scenarios of empirical investigation.[Mau (2020)]

2.4 Two Extensions within Axiomatic Biodynamics

Functional Learning The axiomatic dynamics described above assume capacitances of fixed size which will then be suitable for daily met functional challenges, but insufficient in rarely occurring scenarios with higher demand. The theory was recently extended to *forced functional learning* on a much slower schedule as it is seen in fitness enhancing physical training programs: every few days, an exhaustive functional challenge is introduced and followed by a few days of restoration with a little capacitance increment, see [Mau (2019a)] for details.

Functional Aging A ubiquitous phenomenon human mind is particularly aware of is body system's *functional aging*, which is also of concern in engineered systems. It was shown in [Mau (2019b)] that a slowly changing capacitance of functional *Whole*'s $\{\mathcal{B}|\mathcal{Z}\}$ dynamics can be interpreted as expression of a natural growth process from viewpoint of Linhart chronodynamics, a thermodynamics of progress and hindrance in time, which explains demographic force of mortality as chronodynamic entropic force, see [Starikov (2019)] for details. Here, the relevant time scale is measured in years.

In both extensions, the intensity function concept is more convenient in mathematical formulation; it also lends itself easily to an extension of deterministic equation for stochastification, without loosing the availability of a very detailed and sophisticated statistical theory for estimation of dynamics from measurements, at every functional level.

Further extension of the present axiomatic dynamics, coverage of female cycle as a mensually recurrent dynamics, needs the introduction of oscillatory dynamics.

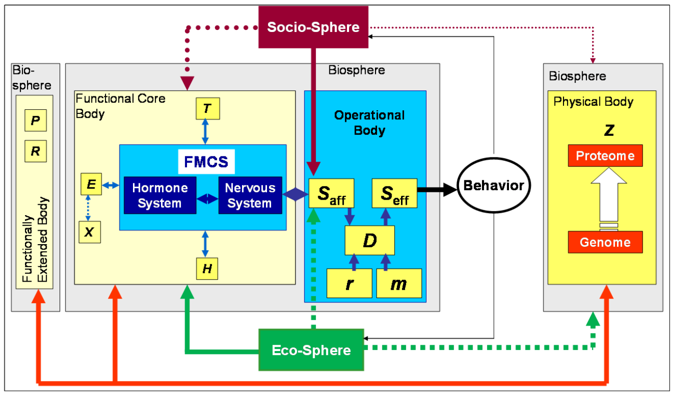

Fig. 4. *Physical, functional and operational body with eco-sphere and socio-sphere feed-back to behavior.[Mau (2016a)]*

2.5 Physiological Controls

In further drill-down from *logical aggregates* on *functional level* one (FL1) in Fig.2, main functional components are depicted in Fig.4. Of special interest for the design of *human-similar AI robots* is an understanding of the *Functional Management and Control System* FMCS which controls all physiological body functions in FL1 aggregates. The following is a very brief orientation, cf. [Hall (2011)] for a thorough textbook description.

Body-system controls number in several thousands, and act within cells, within organs and between all functional components within the whole body. They are mainly of negative feed-back type, but positive feed-back (feed-forward) also occurs, e.g. blood coagulation, nerve firing, female labor upon delivery.

Anatomically, there are two main systems for functional management and control - the nervous system and the hormone system, which are different in speed and reach: the former is fast and point-to-point, the latter uses blood flow in the vascular system, is hence slow and reaches every cell, notwithstanding neuroendocrines and the immune system's role of securing process safety and defense of system-wide well-functioning.

The central nervous system's (CNS) autonomous part controls, for example, arterial blood pressure, body temperature, and more organ functions with more or less occasionally instantaneous soft-muscle activity. The CNS motor function part controls volitive physical motor functions that express in the muscular-skeletal system.

Hormone regulation plays a key role in almost all body functions, for example metabolism, growth and development, water and electrolytes balances, reproduction and behavior.

For consideration of controls in the design of *human-similar AI robots*, scale-invariant control features have to be integrated in a dynamic functional theory for artefactual body systems. While at present only an evidence-based knowledge base can be considered, some differences between females and males, and between different age categories (juvenile, adult, old age), though with little specification, can be expected from system-wide multi-scale interweavement of body-system controls – *human-similar AI robots* will be designed to be aware of it.

3. ROBOTIC SOCIETY

3.1 Tri-partite Life Sphere Concept

The predominant driving force of the living's internal dynamics is its mission set by nature, "live to reproduce!". Notwithstanding an expression of living nature in a variety of "bodies" for different ways of reproduction, the human body $\mathcal{B}(\mathcal{H})$'s "minimal world outside" would have to provide specifically the base $\mathcal{E}(\mathcal{H})$ resources for maintaining the dynamics of $\mathcal{B}(\mathcal{H})$'s physiological functions and a $\mathcal{S}(\mathcal{H})$ social context for a couple $\mathcal{B}(\mathcal{H}) \times \mathcal{B}(\mathcal{H}')$'s reproduction, with $\mathcal{H}' \in \mathcal{S}(\mathcal{H})$ a mating partner of $\mathcal{H}$.

In more detail, the *tri-partite life-sphere* $\mathcal{L}(\mathcal{H})$ *concept* consists of

- a *bio-sphere*, body $\mathcal{B}(\mathcal{H})$ as a biological system of functional dynamics driven by the mission to reproduce and the goal destiny to die;
- an *eco-sphere*: body $\mathcal{B}(\mathcal{H})$'s habitual living space $\mathcal{E}(\mathcal{H})$ in conceptual disregard of social interaction with other people, that
  - · provides *base life resources* (favorable ambient conditions, space to move, to build shelter, to make fire, to grow eatables, to dispose of residuals),
  - · harbors *health hazards* from exposures to living-nature cohabitation (e.g. transmission of pathogens), to civilization (occupational and mobility hazards, industry air, water, soil pollution, urbanization), and geographic setting (climate, natural disasters, emission of toxic chemicals, radiation);
- a *socio-sphere*: body $\mathcal{B}(\mathcal{H})$'s socio-eonomic context $\mathcal{S}(\mathcal{H})$, that
  - · provides *economic opportunities*, and
  - · harbors impact, as hinderance or promotion, from *social embedding*.

All these factors have mostly known – though not fully understood – impact on human-body system $\mathcal{B}(\mathcal{H})$'s functional dynamics, and its cellular material $\mathcal{Z}(\mathcal{H})$, and express in person $\mathcal{H}$'s attitudes, operational decisions, and hence verbal and behavioral communication with his or her life-sphere surroundings;[Diez Roux (2007); Mau (2017)] the respective driving forces of operational dynamics rest, cf. Fig. 1, in person $\mathcal{H}$'s ambitions and adopted roles.[Mau (2016a)]

3.2 Driving Forces of Social Dynamics

Generally speaking, social life is sought for an increased efficiency in exploitation of environmental resources to secure one's life-necessaries, and in protection from environmental threats to life, health, or property as come, *e.g.*, with natural disasters and hostile wildlife.

$\mathcal{H}$'s main impulse for seeking $\mathcal{S}(\mathcal{H})$ interaction instead of leading a hermit life relying totally on own resources is then

- trading own resources for supply with other life-necessity resources,
- learning from others to improve own skills for life fitness, and
- gene-pool access to reproduce and raise off-spring.

One distinguishes a $\mathcal{S}(\mathcal{H})$ micro-context of those other persons $\mathcal{H}'$, $\mathcal{H}' \in \mathcal{S}(\mathcal{H})$ whom $\mathcal{H}$ knows or could get to know personally, and a $\mathcal{S}(\mathcal{H})$ macro-context of social structures that characterize a society. A *human-similar AI robot* has to understand the significance of vital competition among humans in access to life resources.

3.3 Social Micro-Context

This context has two aspects

- in general, $\mathcal{H}$ is member of at least four $\mathcal{S}(\mathcal{H})$ social groups, $\mathcal{H}$'s family and close friends, $\mathcal{H}$'s dwelling neighborhood, $\mathcal{H}$'s workplace or school team-mates, as applicable, $\mathcal{H}$'s leisure-activity mates in $\mathcal{H}$'s clubs, $\mathcal{H}$'s community-life participation, cf. Fig.5, and
- within each $\mathcal{S}(\mathcal{H})$ group, $\mathcal{H}$ is subject to "social control" for $\mathcal{H}$'s behavioral compliance with $\mathcal{S}(\mathcal{H})$ group's standards, cf. Fig.6.

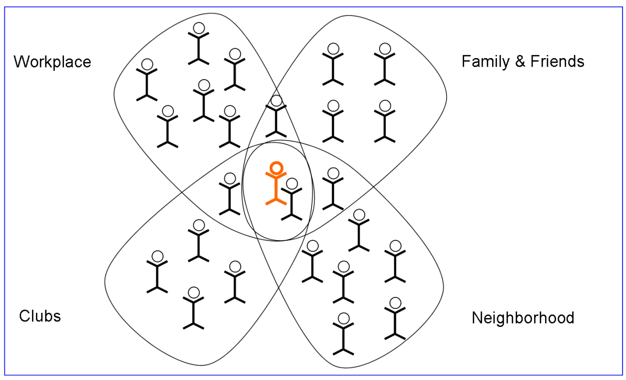

Fig. 5. *Every person $\mathcal{H}$ is member of at least four $\mathcal{S}(\mathcal{H})$ social groups.[Mau (2017)]*

Pursuit of $\mathcal{H}$'s particular ambitions with respect to priorities in trading, learning, and mating will be subject to $\mathcal{S}(\mathcal{H})$ micro-context circumstances, cf. Fig.7.

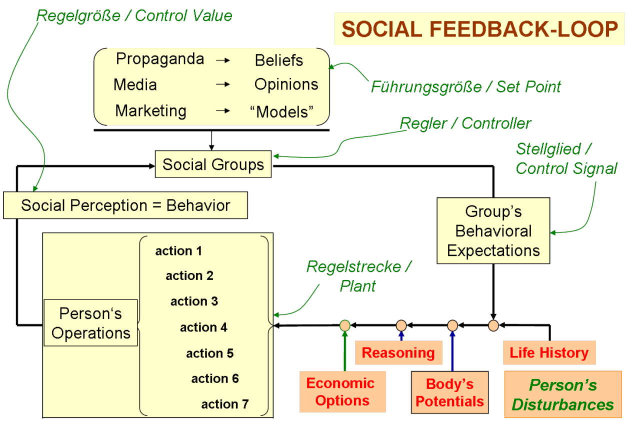

Fig. 6. *Block diagram of the feed-back control loop on behavior of a member of a social group.[Mau (2017)]*

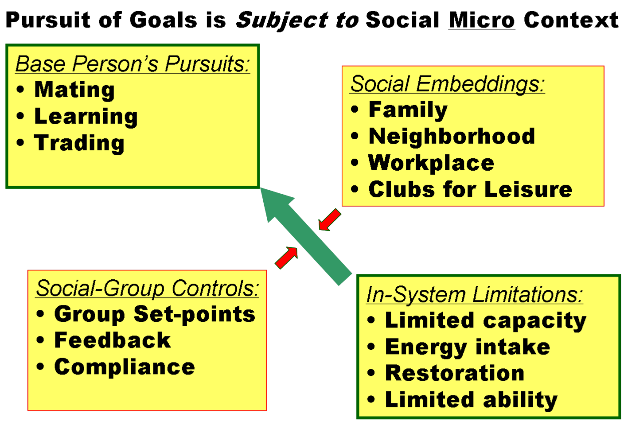

Fig. 7. *Body-system $\mathcal{B}(\mathcal{H})$ limitations may hinder person $\mathcal{H}$'s pursuit of basic aims, and social embeddings with implied controls of person $\mathcal{H}$'s behavior have an impact.[Mau (2017)]*

3.4 Social Macro-Context

Human body $\mathcal{B}(\mathcal{H})$'s vital driving force, preservation of its physical integrity, is energized by an 'in-built' fundamental anxiety about loss of life first and loss of (access to) base resources-for-life, such as food, housing for 'shelter', mobility for 'hunting', education and productivity for manufacturing and trading of necessities, next. $\mathcal{H}$'s social micro context may give comfort, but cannot give enduring reassurance: binding promises need a societal framework for rulings and laws, a kind of 'structural confidence' in a society that is able to guarantee access to said base life resources, including health insurance, social security, and welfare system participation.

Consequently, seeking securement of $\mathcal{S}(\mathcal{H})$ privileges and access to $\mathcal{E}(\mathcal{H})$ resources for self and dependent family, according to opportunity and accessibility is a corollary. Different degrees of distrust into the societal structures to provide a satisfactory level of resources show in distinct behavioral patterns of individuals: 'greediness' (amassing valuables), 'ruthlessness' (taking valuables from others), and 'law-abidingness' (being content with structural provisions). To pacify social competition for life resources, a community will implement culture, ethics, and rulings in binding structures that characterize a society, cf. Fig.8.

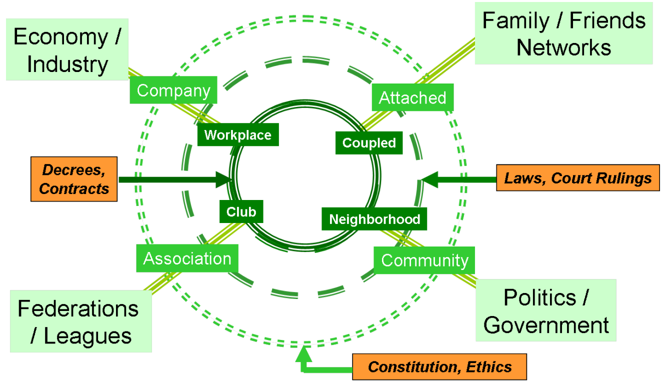

Fig. 8. *Societal structures with interwoven indirect control of a person's behavior.[Mau (2017)]*

4. CONCLUSION

Human-similar robots mean engineered systems that are "similar" to the human body with respect to expression of its internal functional dynamics at each scale level. By their functionally equivalent structure, these machines can virtually "experience" physiological dynamics, effects of internal or external disturbances, and accommodate to shrinking as well as expanding functional capacities in task-solving.

To invest a physiologically *human-similar robot* with an AI-"*mind*" shall add those specific *cognitive* abilities that it needs to notice, analyze and interprete the human counterpart's communication in verbal and behavioral expression with insight from its own state of physiological development, observation and experience – that is, according to matching virtual sex and virtual age – in social context. Connected to it is an understanding of the living's driving forces in social competition about life resources.

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Appendix A. AXIOMATIC DYNAMICS

A.1 Generic Twin-Circuit Dynamics

Consider an *axiomatic "wirkgefüge"* for a single generic twin-circuit $[U_0, R_s, Q_s]|C|[Q_c, R_d, P_e]$ with a "mirror" condensor of capacity C, and

$$[U_0, R_s, Q_s] = [U_0, (R_s(t))_{t>0}, (Q_s(t))_{t\geq 0}] \quad (A.1)$$

$$[Q_c, R_d, P_e] = [(Q_c(t))_{t\geq 0}, (R_d(t))_{t>0}, (P_e(t))_{t>0}] \quad (A.2)$$

for the supply-part and demand-part, respectively. Specific interpretations as in [Mau (2018b), Def. 2] apply:

- a ubiquitous *source* with potential difference (voltage) U_0,
- an accumulated *supply charge* of $Q_s(t)$ by time t,
- a *resistor* with *resistance* $R_s(t)$ for passage control of *supply current* at effective amperage $I_s(t)$ at time t,
- a charge $Q_c(t)$ available on the mirror condenser for the demand-part circuit at time t,
- another *resistor* with *resistance* $R_d(t)$ for passage control of *demand current* of effective amperage $I_d(t)$ at time t,
- an end-consumer with *demand wattage* $P_e(t)$ at time t,

for any $t > 0$; for an illustration as an electric circuit see the diagram in Fig.3.

Assume that voltages, resistances, wattages, lag behind charges Q, which is shown in using their pre-t values, $U(t-)$, $R(t-)$, $P(t-)$. They can then be assumed to have currently fixed values during an arbitrarily small amount of time while accumulated charge on the condensors changes.

The supply-charge increment $dQ_s(t)$ during $[t, t + dt[$ is then

$$dQ_s(t) = \frac{U_0C - Q_s(t)}{CR_s(t-)}dt \quad (A.3)$$

which is tantamount to the first-order differential equation

$$U_0C = \dot{Q}_s(t)R_s(t-)C + Q_s(t) \quad (A.4)$$

with $Q_s(0) = 0$ [Mau (2018b)], that characterize charge-transfer dynamics in the supply-part of the generic twin-circuit.

The demand-charge increment $dQ_c(t)$ during $[t, t + dt[$ is then

$$dQ_c(t) = -\frac{Q_c(t)dt}{CR_.(t-)}, \quad (A.5)$$

with $R_.(t-) = R_d(t-) + R_e(t-)$ for total resistance in the demand part, and

$$R_e(t-) = \frac{U_e(t-)}{I_d(t)} = \frac{U_e(t-)}{\dot{Q}_c(t)} = \frac{P_e(t-)}{\dot{Q}_c^2(t)} \quad (A.6)$$

which gives the quadratic first-order differential equation in Q

$$\dot{Q}_c^2(t) - \dot{Q}_c(t)\frac{Q_c(t)}{CR_d(t-)} + \frac{P_e(t-)}{R_d(t-)} = 0, \qquad \text{(A.7)}$$

that characterizes charge-transfer dynamics in the demand-part of the generic twin-circuit in terms of both the resistance effective in demand-current control *and* the prevalent power demand.

A.2 Extension to Triplet Twin-Circuit

A configuration of three copies of the generic twin-circuit in Fig.3 generates a *triple-circuit "wirkgefüge"* when single twin-circuits are connected in parallel from common source voltage; total current (amperage) and moved charges split however at the branching points into the partial circuits, see Fig. A.1, each a single twin-circuit as in Fig.3 referred to as a *"wirk"-component*. As explained in [Mau (2018b)], the cooperation of these effectuation components at *function level* FL1 emerges as behavior of their aggregate single twin-circuit at next upper *function level* FL0. This phenomenon is called *up-scaling* to next upper function level.

For each replication identified by a subscript i, for $i = 1, 2, 3$, one has (A.3) now as

$$dQ_{si}(t) = \frac{1}{R_{si}(t-)C_i}\left(U_0C_i - Q_{si}(t-)\right)dt, \qquad \text{(A.8)}$$

and (A.5) as

$$dQ_{ci}(t) = -\frac{Q_{ci}(t)dt}{C_iR_{\cdot i}(t-)} \qquad \text{(A.9)}$$

where $R_{\cdot i}(t-) = R_{di}(t-) + R_{ei}(t-)$ for total resistance in the i'th demand-part circuit, and with (A.7) as

$$\dot{Q}_{ci}(t)Q_{ci}(t) = R_{di}(t-)C_i\dot{Q}_{ci}^2(t) + C_iP_{ei}(t-)\ . \qquad \text{(A.10)}$$

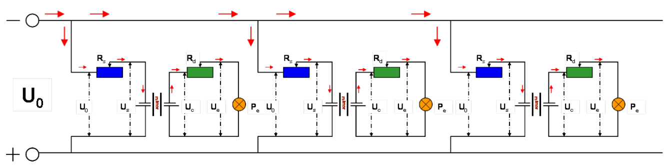

Fig. A.1. *Schematic triple-circuit in parallel connection of three replicates of generic circuit in Fig.3, from [Mau (2018b)].*

For clarity of exposition, the function levels will be shown in superscripts. It suffices to consider those terms at FL0 that arise by summation of corresponding terms at FL1 across the three twin-cicuits there; details are taken from [Mau (2018b)], Sect. 3.2, Theo. 1 and 2. Note, that the parallel connection of the three twin-circuits at FL1 implies the same source voltage U_0, but summation of resistances only in terms of their reciprocals.

For the supply parts, one has

$$C^{\mathrm{FL0}} = C_{\cdot}^{\mathrm{FL1}}, \qquad \text{(A.11)}$$

$$Q_s^{\mathrm{FL0}}(t) = Q_{s\cdot}^{\mathrm{FL1}}(t), t > 0, \qquad \text{(A.12)}$$

$$(R_s^{\mathrm{FL0}}(t))^{-1} = (R_s^{\mathrm{FL1}}(t))_{\cdot}^{-1}, t > 0, \qquad \text{(A.13)}$$

with the "$\cdot$" convention for summation, specifically, $C_{\cdot} = C_1 + C_2 + C_3$, $Q_{s\cdot}(t) = Q_{s1}(t) + Q_{s2}(t) + Q_{s3}(t)$, and $(R_s(t))_{\cdot}^{-1} = R_{s1}^{-1}(t) + R_{s2}^{-1}(t) + R_{s3}^{-1}(t)$.

For the demand parts,

$$Q_c^{\mathrm{FL0}}(t) = Q_{c\cdot}^{\mathrm{FL1}}(t), t > 0, \qquad \text{(A.14)}$$

$$(R_{\cdot}^{\mathrm{FL0}}(t))^{-1} = (R_{\cdot}^{\mathrm{FL1}}(t))_{\cdot}^{-1}, t > 0, \qquad \text{(A.15)}$$

when one considers only the total resistances at the demand-part condensers, $R_{\cdot i}(t) = R_{di}(t) + R_{ei}(t)$.

Appendix B. INTENSITY FUNCTION DYNAMICS

For motivation, consider amount $Q(t)$ of charge transferred by time t, and its t-current first-order dynamics in terms of $\dot{Q}(t)$; the purpose of a factorization is then to express $\dot{Q}(t)$ as a multiple of residual charge t-currently "due for transfer", $Q_{\mathrm{res}}(t)$, say, and to focus then on the proportionality factor, instead.

Though it will later cancel out, the construction of a charge-transfer intensity involves the concept of *maximum charge possible*, $Q_{\max}$, say, as an upper bound to $Q(t)$, and uses t-current charge transferred, $Q(t)$, relative to maximum $Q_{\max}$, denoted by proportion $F(t) = Q(t)/Q_{\max}$, $0 < F(t) < 1$, an isotonic function of $t > 0$, specifically monotonically increasing.

Then, $S(t) = 1 - F(t)$ is another isotonic function in $t > 0$, $0 < S(t) < 1$, though now monotonically decreasing or antitonic, that represents the proportion of residual charge t-currently "due for transfer", $S(t) = Q_{\mathrm{res}}(t)/Q_{\max}$, for any $t > 0$.

Definition 1. In the present context of functions F and S, whenever the derivative $\dot{F}(t) = dF(t)/dt$ exists and $S(t) > 0$, the ratio to the latter defines the *intensity function* of F in t,

$$\lambda(t) = \frac{\dot{F}(t)}{S(t)}, \qquad \text{(B.1)}$$

for appropriate $t > 0$.

Corollary 2. Incremental charge-transfer proportion $dF(t)$ during $[t, t + dt[$ is a multiple of t-current proportion $S(t)$ of charge "due for transfer" and the proportionality factor is the accumulating intensity during $[t, t + dt[$, specifically

$$dF(t) = \lambda(t)dtS(t), \qquad \text{(B.2)}$$

$t > 0$.

This gives rise to consider intensity accumulation over time intervals more explicitly.

Definition 3. In the context of Def.1, the *cumulative intensity* of charge-transfer dynamics in t, $\Lambda(t)$, is defined as

$$\Lambda(t) = \int_0^t \lambda(s)ds, \qquad \text{(B.3)}$$

$t > 0$.
See [Mau (2020)] for a complete elaborate version.