Exploring the Human History: Cybernetic Modeling, Systemic Perspectives, and Applications in Archaeological Eras

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Abstract: Since the 1970s, cybernetic modeling of evolutionary processes has progressed, particularly with the development of the informatics-cybernetic model (ICM). This model conceptualizes humanity as a self-regulating hierarchical network system, continuously tracking energy-based target crite-ria through search optimization algorithms. The outcomes are recorded in the system memory of corresponding hierarchical subsystems. Within the ICM framework, the spatio-temporal charac-teristics of global evolution exhibit modifications reminiscent of the Zhirmunsky-Kuzmin number series, a geometric progression they identified in the exploration of critical levels in biosystem development. The study also showcases applications of mathematical-cybernetic modeling results in understanding historical processes examined by archaeologists and historians.

1. Introduction

Estimating the age of global human history has been approached through various lenses, including the emergence of ancient civilizations, the Upper Paleolithic revolution, and the advent of Homo sapiens. To elucidate this choice, a systemic method becomes imperative. Cybernetic modeling of these processes, a field pioneered by V.F. Turchin (1977), N.N. Moiseev (2001), A.P. Nazaretyan (2004), M.B. Ignatiev (2006), and others, offers valuable insights. Particularly, the informatics-cybernetic model (ICM) conceptualizes Humanity as a self-regulating hierarchical network system. It consistently tracks energy-based target criteria through search optimization algorithms (Rastrigin, 1968, 1979, 1980, 1981; Pervozvanskij, 1970), storing results in the system memory of corresponding hierarchical subsystems (Grinchenko, 2001, 2006, 2007; Grinchenko & Shchapova, 2020a, b) (see fig. 1).

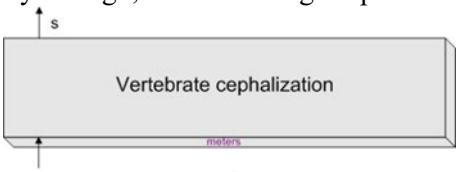
The spatio-temporal characteristics of global evolution within the ICM framework reveal modifications of the Zhirmunsky-Kuzmin number series—a geometric progression with the denominator of e^e, (=15.154..) as identified in their study of critical levels in biosystem development (Zhirmunsky & Kuzmin, 1982, 1988, 1990). This series was found when investigating biological growth where the growth rate is proportional to level at a previous time (i.e., a delay). If there is no delay, then the equation becomes one characterizing simple exponential growth. To generalize, the proportionality constant and the delay might also be time dependent. If they are both not dependent on time, the equation again characterizes exponential growth. As an organism grows, the growth rate follows discrete periods of allometric growth (where the growth rate is inversely proportional to the time). Each distinct growth period has a different scaling factor. The times at which the allometric scaling factors change is called a critical point. The ratios of the critical points seem to follow the ratio of of e^e, (=15.154..). Throughout the process the growth rate decreases with time.

Applications of mathematical-cybernetic modeling results in the archaeological era, along with their alignment with empirical data from paleontologists, archaeologists, and historians, are detailed in the monographs by Shchapova & Grinchenko (2017) and Shchapova et al. (2019).

2. Stages of the global evolution of Humankind's Self-controlling System

From the standpoint of ICM, the stages of complication of information technologies (IT), production technologies (PT), socio-economic formations (SEF) and civilizational structures of the Humanity system in the course of its historical development look as follows (Fig. 2).

0). Cephalization of vertebrates ~428 million years ago, culminating in the emergence of the neocortex ~140.1 million years ago, in catfish ranges up to ~4.2 m in size.



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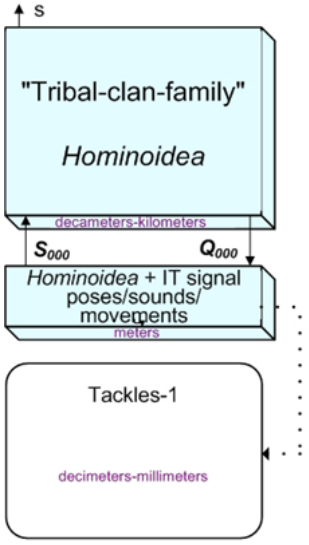
1). The emergence of "pre-pre-humans" *Hominoidea* and the beginning of their development of IT signal postures/sounds/movements ~28.2 million years ago, culminating in the emergence of *Hominidae* ~9.26 million years ago, in the "yard"/ "family" in territories (radius of a circle of the same area) up to ~64 m in size, and with an accuracy of anthropogenic impacts up to ~28 cm.



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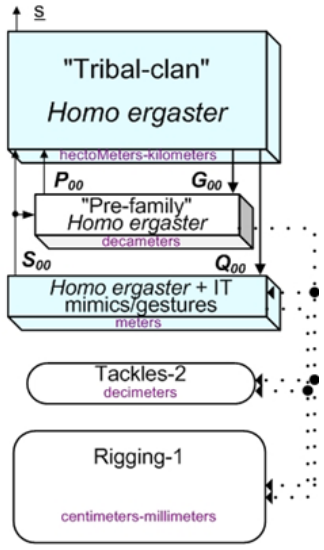
2). The emergence of *Homo erectus/Homo ergaster* and the beginning of their development of IT facial expressions/gestures ~1.86 million years ago, culminating in the emergence of *Homo heidelbergensis* ~0.612 million years ago, in "settlement" areas up to 1 km in size , and the accuracy of anthropogenic impacts up to ~1.8 cm.



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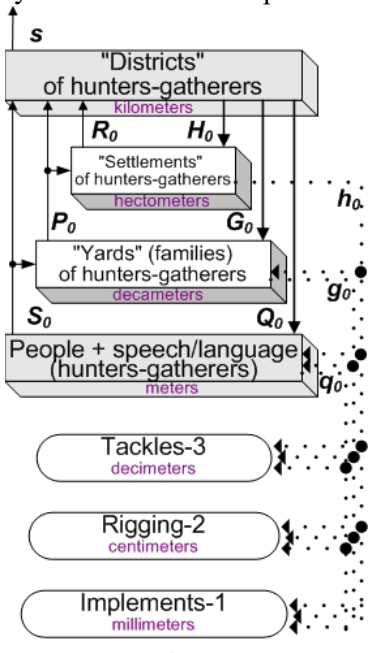
3). The emergence of *Homo sapiens-1* man and the beginning of his development of IT speech/language ~123 thousand years ago, with a culmination (Upper Paleolithic revolution) ~40.3 thousand years ago, in the areas of the "okrug" up to ~15 km in size, and the accuracy of anthropogenic impacts up to ~1.2 mm. The beginning of the development of the General Public Fund "Primitive-communal system" and the first "proto-civilizations".



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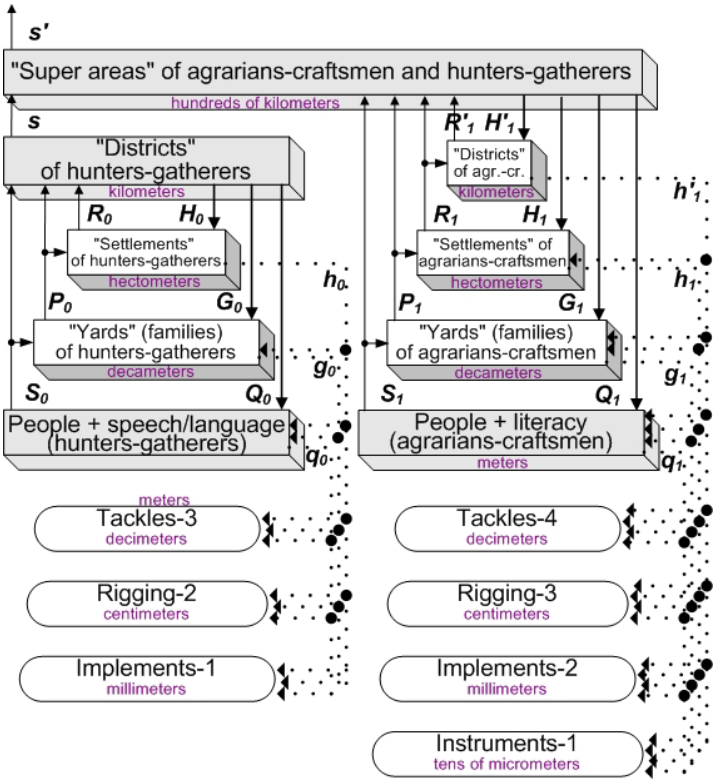
4). The emergence of a complicated human *Homo sapiens-2* and the beginning of his mastery of IT writing/reading ~8.1 thousand years ago, with a culmination (urban revolution of the axial time) ~2.7 thousand years ago, in areas of "super-district" up to ~222 km, and the accuracy of anthropogenic impacts up to ~ 0.08 mm. The beginning of the development of the OEF "Feudalism" and local civilizations.



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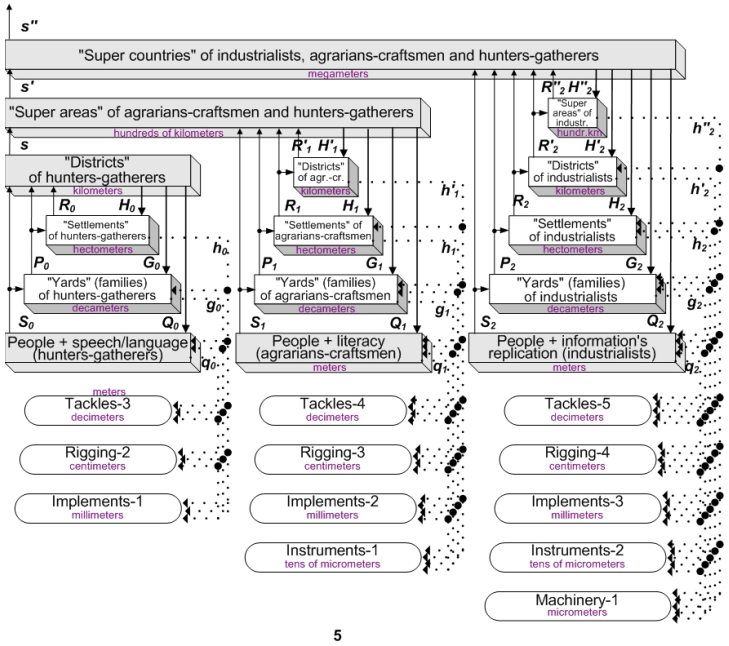
5). The emergence of a more sophisticated human *Homo sapiens-3* and the beginning of the development of IT replication of texts ~ 1446, with a culmination (industrial revolution) ~ 1806, in the areas of the "supercountry" up to ~ 3370 km in size, and the accuracy of anthropogenic impacts up to ~ 5 μm. The beginning of the development of the OEF "Capitalism" and regional/subcontinental civilizations.



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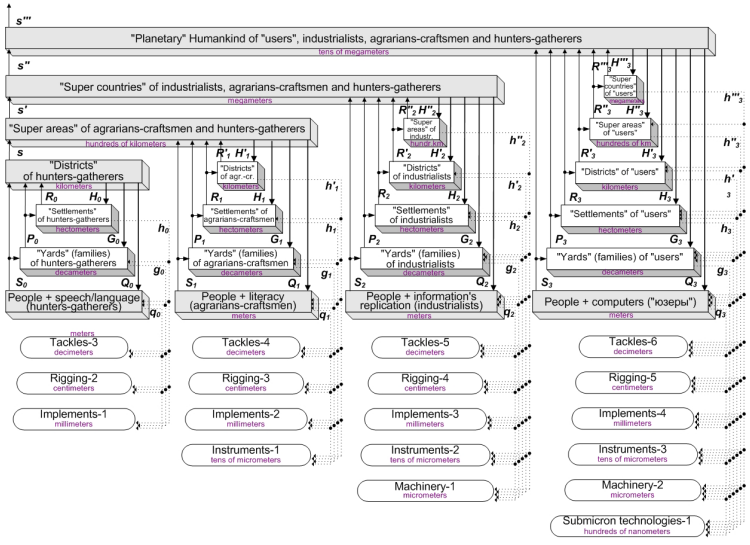
6). The emergence of an even more complicated man *Homo sapiens-4* and the beginning of his development of IT local computers ~ 1946, with a culmination (microprocessor revolution) ~ 1970, in the “Planet Earth as a whole” area up to ~ 51 thousand km in size, and accuracy anthropogenic impacts up to ~0.35 μm. The beginning of the development of the OEF "Digitalism-1" and Planetary Civilization.



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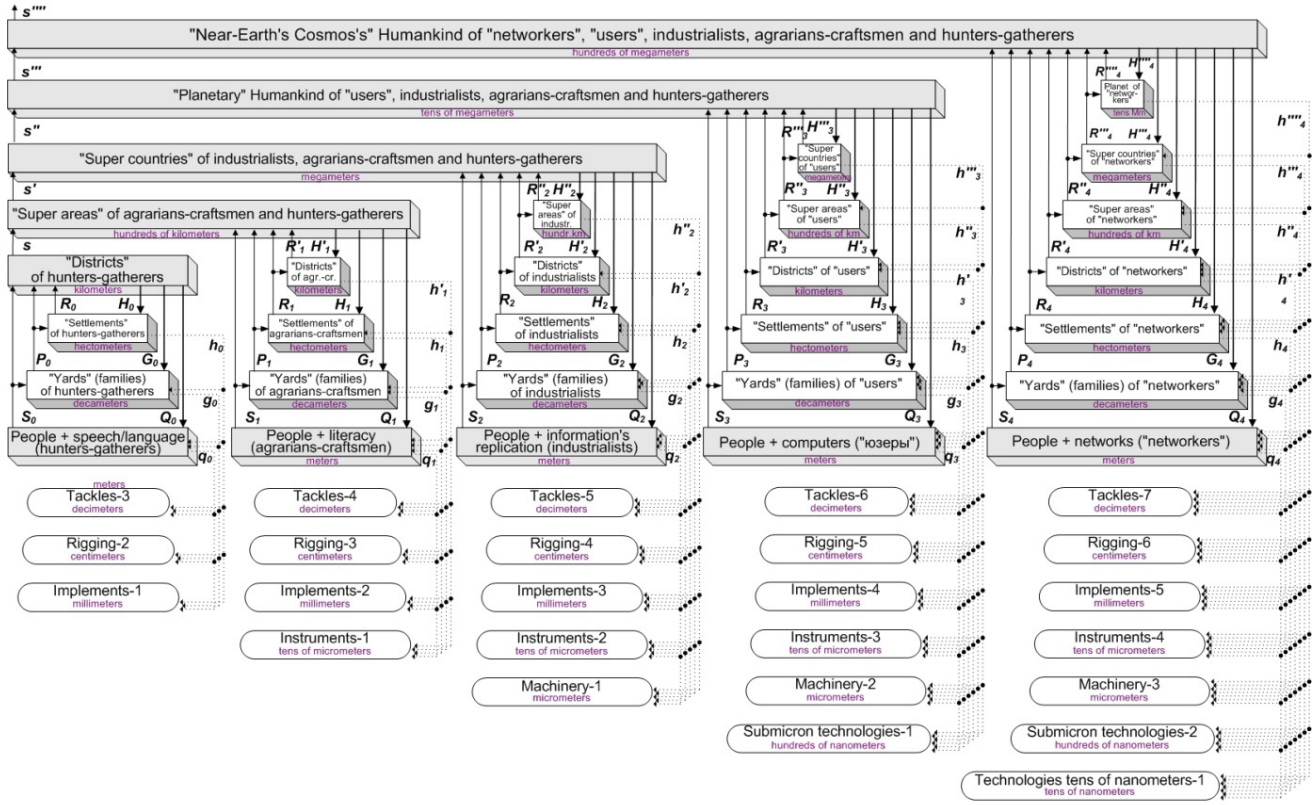
7). The emergence of a more complex human *Homo sapiens-5* and the beginning of his development of IT telecommunications / networks ~ 1979, with a culmination (network revolution) ~ 2003, in the “Near-Earth Space” area



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with a size (radius of a ball around the Earth) up to ~773 thousand km, and the accuracy of anthropogenic impacts up to ~23 nm. The beginning of the development of the OEF "Digitalism-2" and the Civilization of the Near-Earth Space.

8). The emergence of an even more complex human *Homo sapiens-6* and the beginning of the development of promising nano-IT ~ 1981, with a culmination (nano-revolution) ~ 2341, in the Intermediate Space area up to 11.7 million km in size, and accuracy anthropogenic impacts up to ~1.5 nm. The beginning of the development of the OEF "Cyphralism-3" and the Civilization of the Intermediate Space.

At the same time, the following is fulfilled: the principle of systemic cumulation: the emergence of new systemic entities does not mean the elimination of similar ones that have previously arisen; and the principle of systemic consistency: this emergence is accompanied by cardinal complications in the structure and adaptive behavior of those that have previously arisen, with a decrease in their relative role (Grinchenko, 2020).

The evolution of basic information technologies stands as a distinct "stream" within the broader context of systemic global evolution for Humankind. This progression intertwines with various parallel sequences, encompassing the development of production and macro-structural technologies (Grinchenko, 2007), shifts in socio-economic formations (Grinchenko, 2021a, 2022a), the evolution of civilizations in diverse forms (Grinchenko, 2011, 2021b, 2022b), the configuration of the substratum of the collective unconscious (Grinchenko, 2020c), the phenomenon of "multidimensional hierarchical territorial sovereignty" (Grinchenko, 2022c, d, 2023), classifications of informational and military weapons (Grinchenko, 2022e, f), challenges related to global Internet dominance (Grinchenko, 2022g), the dynamics of "communication" (Grinchenko, 2022h), the intricacies of "upbringing" (Grinchenko, 2022i), the stages of cultural development as a "second nature" (Grinchenko, 2020d), the systemic education level of individuals (Grinchenko, 2022j), the phases of global educational system evolution (Grinchenko, 2021c), and the phylogeny of personality (Grinchenko, 2019), among others.

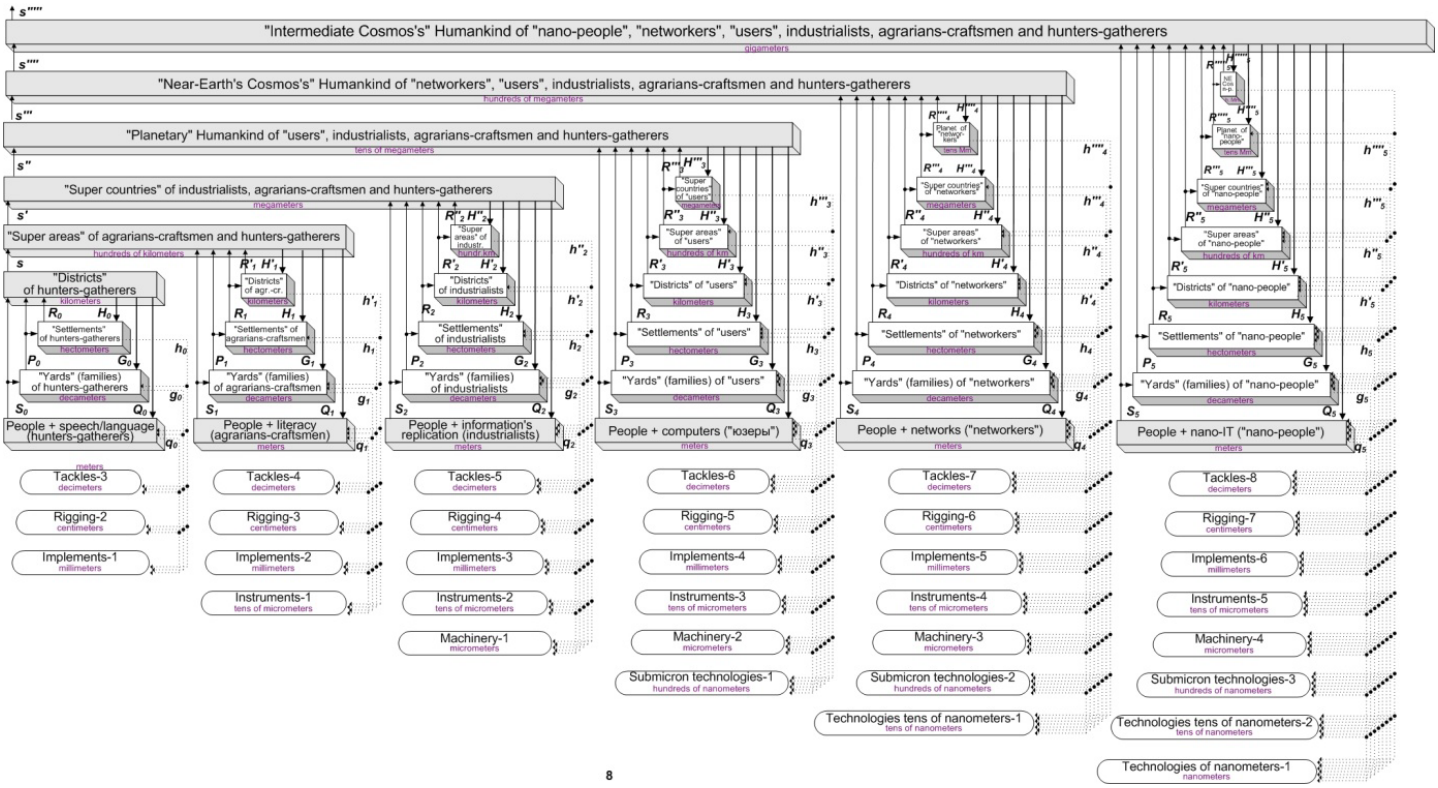

Fig. 1. (Stages 0-8 above) Hierarchical structures of the global evolution of the personal-production-social nature ***Notes to the figures****: ascending arrows, having the "many-to-one" structure, reflect the search activity of representatives of the corresponding tiers in the hierarchy; descending solid arrows, having the "one-to-many" structure, reflect the target criteria for search optimization of system energy – extreme, with constraints such as equalities and inequalities; descending dotted arrows, having the "one-to-many" structure, reflect the systemic memory of the personal-industrial-social – the result of the adaptive influences of representatives of the overlying hierarchical tiers on the structure and behavior of the underlying ones embedded in them.*

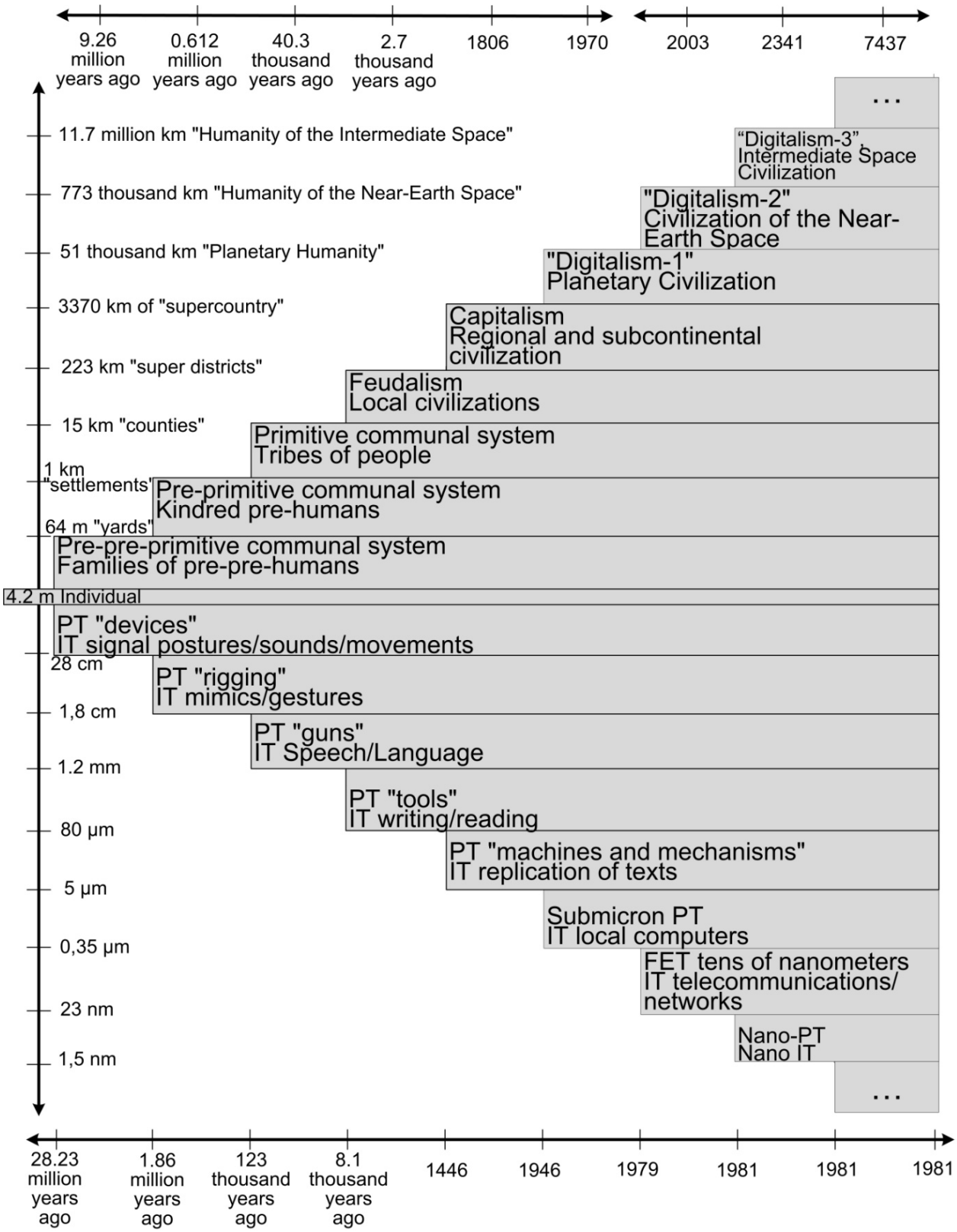

Fig.2. Stages of the global evolution of a self-controlling system of Humanity.

Conclusions

Cybernetic interpretation of the self-regulating hierarchical network system of humankind, indicates a rich unfolding across its sequence of stages. The increase in complexity of information, production, and organizational processes can be identified and diagrammed during these 7 evolutionary stages—from the emergence of Hominoidea about 30 million years ago to the present. This sequence presents promising insights for future predictions for the next stage.

Furthermore, the fact that a specific natural process can be delineated by a mathematical expression (often of the simplest kind) implies its inherent reliance on fundamental laws of the universe. This paper extends this characteristic beyond the realms of inanimate and living nature explored by Zhirmunsky to also encompass cultural aspects as a unified whole. This suggests that regardless of the perceived "freedom" exercised by individuals and the societies they forge, the laws of the universe persist, determining the primary coarse trajectories of global evolution within the overarching narrative of Big History.

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