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Theory of Futuribles

Each field of scientific knowledge has its intrinsic canon of sufficient legitimation. Knowing about the future is no exception; futurological canon legitimizes beliefs and opinions about the future as knowledge of the future. At the moment, however, this canon is more implicit in a plethora of approaches, mindsets, and methodologies applied in futures studies than explicitly stated. Conception of the futures manifold is implicit in many approaches and mindsets of the futurological inquiry, and to study it is the object of the paper.

Instead of considering the future as a single pre-determined case, a fan of possible futures, called futuribles is considered as a proper object of futurological conjecture. The manifold conceptualization of the future has a long history from Luis de Molina and others in the 16th century to Bertrand de Jouvenel in the 1950s and 60s. The logical theory based on the manifold conceptualization has not as yet, however, been fully analyzed. The authors develop a general set-theoretic construction, called a theory of futuribles for futures knowledge inquiry. New concepts of futures space, futures galaxy and futures multiverse as well as synoptic difference and distance, local and egocentric transitivity of the distance measure are deduced.

Key words: futuribles, theory of futuribles, futures manifold, futures knowledge, scenario, futures space, synopsis, synoptic distance, local and egocentric transitivity

Introduction

A wish to know about the future is known to be human intellectual characteristic since Antic Greece and Rome, as Robert Nisbet[1], Wendell Bell[2], Ossip K. Flechtheim[3], and Sirkka Heinonen[4] among numerous others have pointed out. Interest in the future can be traced back even to the ancestors of Homo Sapiens, as exemplified for instance by Y. Coppens with archeological findings[5], by Riane Eisler with her studies of women's roles and the construction of social systems[6], or Tom Lombardo[7] in his essay on the prehistoric evolution of future consciousness. One can say that the future was invented by the emerging consciousness of mind at the dawn of humankind.

Scientific knowledge is nothing else than a well grounded true belief. All sciences from mathematics or natural sciences to social and humanistic sciences stick in this as an epistemological commitment. It means that a subjective belief, intuition or opinion is accepted as objective knowledge when there is sufficient evidence to "legitimate" that the belief is true and credible. However, there is no universal theory of truth to be referred to by all the sciences; each of them has its intrinsic canon of necessary and sufficient legitimation, and the canons are not fully compatible with each other. In sciences, however, one canon shall not be contradictory with another, even though there is no ultimate authority but only open scientific discussion to resolve discrepancies that might appear. No canon can be internally inconsistent or against the laws of Nature. Knowing about the future makes no exception in these respects.

In another respect, however, knowing about future is different from knowing about the past and present. Unlike the past or present, the future does not materialize to our senses, when a desire to know about it appears in the human mind. Knowing about the past and present can be grounded on factual material evidence, but conjecturing the future relies on non-factual and intentional data.

Futurological inquiry has its intrinsic canon for legitimizing beliefs and opinions about the future as knowledge. At the moment the futurological canon is more implicitly present in a plethora of case studies, approaches, mindsets, and methodologies applied in futures studies, than explicitly stated. An updated source for the methods is found in the Millennium project's publication Futures Research Methodology Version 2.0[8]. There is, however, a need for basic futures research to recognize that 'knowledge of the future' is generalization of the knowledge of the past and present. In this paper the authors develop a general set-theoretic construction, called a theory of futuribles for futures knowledge inquiry.

Knowing about future

Future is no entity but a continuously unfolding process, to be forethought in the mind scenery. The past constraints the future unfolding - the future remembers some of the past - but the past never fully determines the future course. The future is not a deterministic consequence of the past, but there are many factors at any time which have effects on the realization; the factors may be random "fluctuations", chance "disturbances" or natural "shocks", "structural change", or human "interventions", etc. In system language the future process is under-determined by the past and its realizations will be determined behind the curtain of generic indeterminacy. Knowledge about such a contingent "under-determined object" is necessarily uncertain, i.e. knowledge of the future is irreducibly contingent.

Futurological knowledge is "true" if it asserts something that is not impossible in the material world, or something that is not impossible for humans to make real. The wide use of foresight methods and material produced by futures studies indicate that scientifically grounded contingent knowledge is important and vital to modern societies. Futurological inquiry is concerned particularly with intentional human deeds and their effects. Intentionality is one of the aspects which make the futures study essentially more general than natural science or other studies of non-intentional objects.

The essence of intentionality was well articulated by Ossip. K. Flechtheim in his book Der Kampf um die Zukunft[3]. According to Flechtheim the scientific discipline, that he as the first one called futurology in the 1940s, intents to contribute to (op.cit. p.9): eliminating war and institutionalizing peace, eradicating hunger and poverty and stabilizing world population, democratization of societies, protecting Nature from over-exploitation, and humans from themselves, and preventing alienation by giving rise to new creative Homo humanus. The modern futures studies have no objections to these intentional challenges today.

Ossip K. Flechtheim also outlined four presumptions necessary for accomplishing the intentional challenge of futurology (op.cit, p.16). The first assumption holds that the world is considered dynamic whereby not only its temporal states change but also its basic structures generating the states do change and new options of human interest emerge from the changes. Secondly, the possible changes are partly recognizable beforehand and the directions and speeds of the changes can in some instances be roughly predictable. Thirdly, antithetical forecasts and projections also have some value; they can contribute to the clarification of problems and to specifying time, place, area, or degree of probability and consequences of crises. Fourthly, within the frame of the conditions determined by the past there is a freedom for human choice to make an effect on the future and to create alternatives and shape the future unfolding. Also understanding of what is necessary and out of human reach, or possible and desired, or what is unnecessary and avoidable contributes essentially to shaping the future. We can well agree also with these presumptions today.

The possibility to intervene by free will in the course of the future and to pursue human intentions is a fundamental commitment but not always easily accepted. A strongly controversial dispute about the possibility of free will took place in the Catholic Church towards the close of the 16th century[9], and this has relevance also to modern futurological discussion. The debate was fuelled especially by Luis de Molina's book Concordia[10] published in 1589, where this scholar offered a logical explanation for free will, foreknowledge and predestination. He argued for freedom and indeterminism in the world and he has been credited with introducing a concept of 'conditional future contingents' or "futuribilia" (Molina Luis de [9]). It is not, however, sure that the term futuribilia was really coined by de Molina even though he was the father of the idea; his important texts have as yet not been studied rigorously enough from the modern futures studies point of view[iii].

Conception of futuribles

De Jouvenel, in his classic The Art of Conjecture[11] (p.15) and Flechtheim, in his History and Futurology[12] (p. 105) referred to de Molina. Bertrand de Jouvenel picked up the idea of "futuribilia" and combined "future" and "possibility" together into a new term "futurible".

De Jouvenel defined futuribles as a fan of possible futures, and he states that futuribles designate what seems to be the object of thought when the mind is directed towards the future (op. cit p. 18 and 20). This indicates that the futuribles is a "multifold object" of forethought. Our mind is unable to grasp with certainty the things which will be or all intentions which may intervene in the process, but it can conjecture possible alternatives. There are many states of affairs which we have no reason to regard impossible in the future; it follows, in accordance with the law of contradiction, that we can regard them as possible. A possible future state enters into the class of "futuribles" only if it originates from the present. Futurible is an element of analytical and semantic construction of the futures process comprising economic and technological, political and social, cultural and environmental issues.

Presumptions of determinism, predetermination, or prophesying do not belong to the futurological knowledge creation. Predicting, forecasting, extrapolating, simulation and decision modeling, and planning procedures are instead valuable approaches in futurological inquiry. Their use calls, however, for more careful consideration of validity and reliability than for instance in natural science studies. Predicting the moon orbit around the earth in astronomy is relatively easy because there are no intentions or possibilities to change the orbit deliberately, and predicting the orbit of a satellite is possible because the prevailing intentions are well known and strictly managed. Human societies are different, fortunately!

De Jouvenel presented also the following important assertion. If an exhaustive enumeration of the possible futures at any hypothetical present could be assumed possible, it would lead to the untenable consequence that there is a progressive reduction of uncertainty of futures knowledge in general. Therefore, there is no time at which we can enumerate the futuribles exhaustively, concluded de Jouvenel.

Futurible-conception, i.e. the manifold of possible futures, is well accepted in modern futurological inquiry. Growth of the popularity of scenario writing since the 1960s demonstrates this well, as exemplified by the sample of the references[13] of recognized experts, such as Michel Godet, Ian Wilson, Eleonora Masini, Jerome Glenn and Theodore Gordon, and by several reports to the Club of Rome since the 1972. Possibilities which the conceptualization offers to futures studies have not as yet, however, been comprehensively utilized.

The objective of this study is to present a logical framework of the futurible-conception which is called a theory of futuribles. The theory is deduced from the morphological setting called a generic table of the futures space.

Map analogy

The study approach is illustrated with an analogy of ordinary mapping which everybody is familiar to. A map tells us something but not everything about scenery assuming that one can read the map and interpret its messages. The map is a source of information about the scenery, a symbolic replica of some characters of it. There is a relationship between the map's designs and symbols and the real scenery at some level of coarseness and vagueness. A map is not the territory. One cannot walk on the map, and neither are trees growing nor lakes opening before one's eyes on the map or smells and sounds sensed as in the real scenery. The map is anyhow useful when planning a project in the scenery or wishing to foreknow what kinds of experience one might be able to sense there and possibilities different places would be suitable for.

Robert Osserman offers an excellent general account of mapping in his book Poetry of the universe[14]. In an analogous way we see the futures manifold as a symbolic representation of the future, i.e. it is a kind of a map.

Were similar maps of futures scenery available or were it possible to design them, they would certainly be of service to our undertakings for the future and foreseeing possible options of the future.

In geographical mapping the elementary symbols and patterns of the map represent different elements of the scenery, e.g. trees, lakes, meadows, cliffs, buildings, roads, or spatial relations between the elements like height differences, distances, steepness, etc. During the centennial time of development in cartography it has become possible to agree internationally on common standards for map design, i.e. symbols used, ways to represent spatial relationships, or scales of the maps.

In the same way a futures manifold is a symbolic representation of the future, i.e. it is a kind of a map. But the "futures cartography" is still in its infancy. There are no standards for symbols of social issues, or how to present, for instance political relationships and power dependencies and qualitative transformations. There are no criteria for which issues really matter in the future or which of them would generally be important enough to be selected for a mapping. In addition it might be desirable that a futures map is more of a playground for competition and action than a description of the state of affairs as such. When the intentional points matter, the futures cartography aims at a unique product for a given purpose. All this does not make, however, futures mapping any less important in general. Futures studies can benefit from the analogy of mapping.

Requisite coarseness of resolution is an important logical aspect in any mapping. In a geographical map there may be both elementary items of the scenery, e.g. a tree, or a cliff, and also some larger units of scenery like forests of different kinds, swamps, fields, water systems, industrial areas, housing areas, etc. Different types are often mutually exclusive, i.e. if there is a lake there is no road in the same place, and if a swamp then no corn field, but this is not always a necessity. In a swamp there may be forest, and a road can go along a river bank or cross a lake. Logical separateness and mutual exclusiveness is a vital methodological character to be preserved. This requirement can be fulfilled by defining compound scenery types of richer information. A scenery type 'swamp with fir forest', or 'lake with a bridge and road across' serves as an example of finer resolution. On the other hand, the resolution can be made coarser by withholding information that does not matter, as is often done for instance on highway maps. Unavoidable vagueness is left in any mapping, which may be managed somehow with a diversity of maps. Vagueness is for sure also unavoidable in futures mapping, and to a certain degree it can be managed by choosing the coarseness of resolution accordingly, but as noted earlier, an enumeration of the futuribles is not possible and knowledge of the future is at no time converging towards a "real" future.

A futures map is a generic design of the futures manifold and a symbolic representation of what might unfold or be realized by human interventions in the material world.

Generic design of futures manifold

Futures manifold

Designing a futures map starts by identifying the issues which are regarded as vital and relevant in the study; they are called futures variables. Each variable has a name tag, e.g. "economic growth", "export", "aging rate of population", "literacy rate", "dematerialization", "equality", "rebound", "environmental stress", "energy need", "material consumption", "technology development", "welfare productivity of GDP" illustrate futures issues and variable names. Each issue is itemized into mutually exclusive, alternative possibilities of the issue variety. The items of the issue variety are called value elements of the variable and the total set of them forms the domain of the variable in the study.

Let the futures variables be denoted by X_i, (i = 1, 2,…, K), where K is the number of identified variables. The domain of the value elements of variable X_i is a set of the varieties $\{x_{ij} \mid j=1, 2,\ldots, n_{ij}\}$, where n_i is the number of the different values of X_i.

When an issue is apt to quantitative measurement, the value elements of the variable are quantities. Futures variables may also be measurable only on an ordinal scale, or it may represent plain qualitative aspects of the future on a nominal scale. If all the values in a domain are the same, i.e. the variable has only one value, the variable is called a futures constant; for instance, until today the planetary conditions of the Earth have been generally regarded as constant; nowadays the possibility

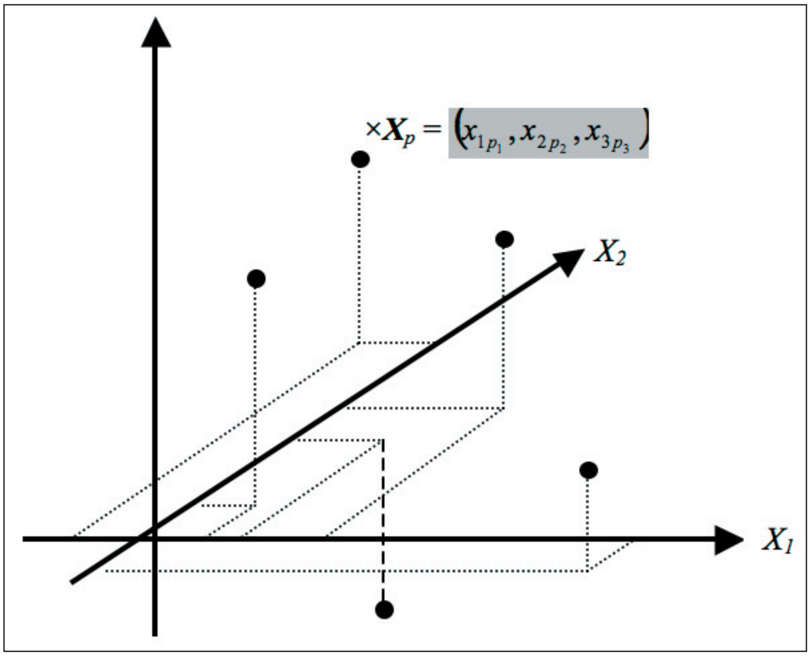


Figure 1. Illustration of the futures manifold as a coordinate system

of an irreversible climate change has transformed that aspect from a futures constant to the class of variable. A variable having a domain of a few values only may be taken to serve as a futures parameter; the parameter can be used for partitioning the futures space into mutually exclusive sub-spaces. The partition can be seen as analogous to presenting a map of the Globe with the maps of the Eastern hemisphere and Western hemisphere. In summary we get a definition of the futures manifold (1) to (3):

Let the collection of the futures variables X_i be symbolically denoted by the variable set X. We then have

(1) $X = \{X_i \mid i = 1,\ldots,K\}$.

The value domains of the variables are

(2) $X_i = \{x_{ij} \mid j = 1,\ldots,n_i\},\ i = 1,\ldots,K.$

The elementary system defined by (1) and (2) is called *a futures manifold* $\mathcal{X}$. It can be interpreted as a K-dimensional coordinate system "spanned" by the variable set X. The futures manifold $\mathcal{X}$ can be symbolically presented as a set of "K-dimensional Cartesian points" $\times\boldsymbol{X}_P$, i.e.

(3) $\mathcal{X} = \{\times\boldsymbol{X}_P \mid \times\boldsymbol{X}_P \in X_1 \times X_2 \times \ldots \times X_K\}.$

In Figure 1 the coordinate system of the futures manifold is schematically illustrated, with points ($\times\boldsymbol{X}_P$).

Generic table of the futures manifold

The system $\mathcal{X}$ of (1) to (3) is possible to represent alternatively in the form of a table. For each futures variable X_i a row i of the table is designated and to each value element x_{ij} of the variable X_i a cell (i, j) in that row is designated. The resulting table of the manifold is called the generic table. The generic table obviously has K rows and a number n_i cells in each of the rows. A design of the generic table is illustrated in Figure 2. The generic table and the coordinate system are isomorphic equivalents of the futures manifold $\mathcal{X}$.

In Figure 2, the bottom row has only one value element in the domain; the respective issue is a constant futures background and the variable a futures constant. The next two variables just above the bottom row have three value elements and the second variable has four cells in its domain. They represent a conventional futures variable with a given domain. The uppermost variable has two values. This variable could be regarded, if relevant, as a futures parameter. With the values of the parameter the manifold in Figure 2 can be partitioned into two mutually exclusive sub-manifolds, as will be explained later.

Figure 3 shows a concrete example of a generic table taken from an EU study[15]. For layout reasons the table in Figure 3 is presented in a "transposed form", i.e. the five (K=5) futures variables appear horizontally and their value domains (with 4 to 5 cells) vertically. The non-shaded cells in the table combined represent a point in the K-dimensional futures space.

The generic table is a morphological map of future "sceneries", i.e. repre-

Futures variable	Generic table				# cells	Interpretation of the type of the variable
X_1	x_{11}	x_{12}			2	an optional parameter
X_2	x_{21}	x_{22}	x_{23}	x_{24}	4	a variable
X_3	x_{31}	x_{32}	x_{33}		3	a variable
X_4	x_{41}	x_{42}	x_{43}		3	a variable
X_5	x_{51}				1	a futures constant, background
K=5	M=13				$\bar{n}$ =2.6	

Figure 2. Generic table design of a futures manifold

2. Technology / Organisation	3. Culture / Values	4. Globalisation	5. Macro economic policies (EMU)	7. Social and employment policies
No major breakthrough. Downsizing. Continuing de-specialisation of Europe in high-tech.	Increasing individualism. Fear of the future.	Globalisation continuing, sectoral resistances, local difficulties.	Broad EMU with limited coordination and no major tensions.	Continuing "decremental" adjustment of social protection.
No major breakthrough. Increasing dualism. Increasing de-specialisation of Europe in high-tech.	Strongly increasing individualism. Social and geographical segregation. Power of lobbies.	Globalisation accelerating. "Borderless world"	Broad EMU with limited coordination and major tensions.	Strong labour market deregulation. Residual welfare state.
Major breakthrough. Europe innovating and/or catching up.	Renaissance of social/ecological awareness. Regions/localities experiments.	Globalisation slowing down, trade conflicts, regional blocks.	Broad EMU with strong coordination.	Strong resistance against welfare state reform.
Major breakthrough. Increasing technologically induced inequality. Europe catching up.	Revolt of the bottom-half against globalisation.	Global crisis	Failure of EMU	Radical reform of welfare state: universalism and individual incentives.
Major breakthrough. Increasing technologically induced inequality. Europe falling behind.				

Figure 3. Generic table of an EU study; the futurible of the non-shaded cells is called the “Laissez faire” future in the study. The table layout is transposed as indicated in the text. (Source: Scenarios Europe 2010)

sentations of the possible futures. Each futures issue or a variable has multiple varieties, i.e. each row of the table has different number of cells. The number of the cells in a variable row gives an indication of the coarseness of resolution of the issue presentation. The more cells there are, the finer is the resolution, and vice versa.

If the number of the variables in the generic table is K and the i^{th} variable has n_i value elements, then the total number of cells in the table is M given by equation (4):

(4) $M = \sum_{i=1}^{K} n_i = K \cdot \bar{n}.$

Metaphorically, the number of futures variables K refers to the extension of the futures space – the bigger K the farer the horizon of the space from a centre. The mean number of the cells per row $\bar{n}$ implies the mean issue resolution. The number M, i.e. the product of the extension and the mean resolution indicates the total expressiveness of the manifold under study.

Syntactic design of futures mapping

An element of the futures manifold in (3) and equivalently a point in the coordinate system in Figure 1 is called a synopsis. In the generic table it is defined as follows: a synopsis is an exhaustive and exclusive collection of values of the successive variables, i.e. the synopsis is a design composed of one and only one cell from each variable row of the table. Formally a synopsis, F_q, is defined by (5):

(5)

In formula (5), N stands for the maximum number of separate synopses. It depends on the number of the possible values of the variables in their domains according to the multiplication formula (6)

(5) $F_q = (x_{1q_1}, x_{2q_2}, ..., x_{Kq_K}),\ q = 1,...,N;\ q_1 \in \{1,...,n_i\},\ i = 1,...,K.$

(6) $N = \prod_{i=1}^{K} n_i = n_1 \times n_2 \times ... \times n_K.$

There may be some bans which negate the simultaneous presence of some values of distinct variables wherefore the number of feasible synopses may be smaller than the number of all synopses N. The given generic table forms the background of the study and synopses. Therefore a synopsis includes also information of the particular address of the elements (row and cell number) picked for it. For example, one synopsis of the table in Figure 2 is $(x_{11}, x_{21}, x_{31}, x_{41}, x_{51})$. To show this synopsis on the background of the whole table we present the table as a long row of all variables one after the other as follows: $[(x_{11}, 0),(x_{21}, 0, 0, 0),(x_{31}, 0, 0),(x_{41}, 0, 0),(x_{51})]$. This presentation shows what other choices are possible on the same background and that the choice made is a picking of this certain alternative.

For rationalizing this notation the following Dirac's Delta type table D^q is introduced. D^q is a table with the same number of rows and cells and the same format as the generic table. Each cell value of the D^q-table is either 0 or 1 in such a way that each row contains one and only one 1. Let the i^{th} row ($i = 1,2,...,K$) of the D^q-table be denoted by D^q_i and let us further assume that it has its non-zero element in the position $p_i \in (\{1,2,..., n_i\}$, i.e. $D^q_{ip_i} = 1$ and $D^q_{ij} = 0$, when $j \neq p_i$. The table element $D^q_{ip_i}$ can be used to pick a cell value x_{ip_i} from address p_i of the futures variable X_i in the generic table. Together all the D^q_i -rows with $i = 1,..., K$ and $p_i = 1,2,..., n_i$ pick an exhaustive set of the value elements of the futures variables that constitutes a synopsis. The Dirac's Delta table thus defines the formal picking of a specific synopsis from the set of all synopses within the generic table. The set of all Dirac's Delta tables is presented by a notation of $\boldsymbol{D} = \{D^q\}$.

With the D^q -table notation a synopsis F_q of $\mathcal{X}$ can be presented with a scalar product operation (denoted by $\cdot$) between a row of the generic table $\mathcal{X}$ in (3) and of the Dirac's Delta table D^q:

(7).

As defined above, the symbol D^q_i in Formula (7) denotes the ith row vector of the table D^q and X_i is the i^{th} row of the generic table $\mathcal{X}$. The operation in (7) results in a vector F_q whose components are scalar products of the row vectors of the tables D^q and $\mathcal{X}$. There is one to one correspondence between this result and the previous notations of $\{\times \boldsymbol{X}_p\}$ and $\{F_q\}$.

The futures space $\boldsymbol{F}$ is defined as the set of all synopsizes $\{F_q\}$ spanned by the whole generic table $\mathcal{X}$. With the notation of $\boldsymbol{D}$ the futures space will have a simple expression as a "multiplication" operation (denoted by symbol $\circ$) with the generic table $\mathcal{X}$

(8).

Futurible - a basic unit of futures mapping

The synopsis concept belongs to the syntactic design of futures mapping; it is a logical form of a possible future. Synopsis and futurible are synonymous equivalents in the sense that futurible is a semantic counterpart of synopsis. Futurible refers to the content, while synopsis gives the logical form in which the content is to be presented. The whole set of synopses in (8) also means the fan of the futuribles mapped onto the generic table $\mathcal{X}$, and F_q denotes also a futurible.

Each futures variable defines an independent dimension of the future into which direction the futures stories can be told and varied within the domain of the variable. The generic table with its K variables spans a K-dimensional futures space, where each futurible

(7) $F_q = (D^q_i \cdot X_i \mid i = 1,2,...,K) = (D^q_1 \cdot X_1, D^q_2 \cdot X_2, ..., D^q_K \cdot X_K).$

(8) $\boldsymbol{F} = \{F_q \mid q = 1,...,N\} = \{(D^q_1 \cdot X_1, D^q_2 \cdot X_2, ..., D^q_K \cdot X_K) \mid q = 1,...,N\} = \boldsymbol{D} \circ \mathcal{X}.$

represents a map of a possible future "scenery".

It is plausible, as mentioned earlier, that relations of one kind or another may exist between futures variables denying a possibility of some values to coexist. In addition, constraints may occur also between futuribles to follow each other. Some futurible may be a necessary condition for another one, and this in turn to yet another one etc., while constraints of another type may deny a succession between futuribles. For instance, the present which in the logical sense is also a synopsis and a "futurible", is a necessary though not sufficient condition for any futures to come. The present does not predetermine the course of the successive futuribles, but neither does it leave the course of the future unconstrained. From the synopsis of the present several possibilities are open for futuribles to unfold. Some possible courses of the future may divert from each other irreversibly depending on the different constraints, while other courses may pass through the same futuribles. It is, in addition, well grounded to assume that in the course of the future a given futurible may be reachable from several preceding ones but not from whichever futuribles. A possible chain of futuribles is called a course of the future. Futuribles as well as futures courses may be attached with specific attributes such as probable, desirable, avoidable, non-feasible, or a threat, a utopia or a dystopia.

Synoptic difference and synoptic distance

The futures variables are most frequently qualitative issues "measured on nominal scales". We can speak about a synoptic difference between futuribles only in a specific meaning. When one or more futures variables of two futuribles assume a different value there is a synoptic difference and a synoptic distance between them. Semantically, the values of a variable differ from each other qualitatively, and the same holds necessarily also with the differences between the futuribles. Therefore a distance from one futurible to another can not be defined in any metric sense. The only quantitative information concerning the differences is the number of the variables which assume different values in the corresponding futuribles. The concepts of synoptic difference and distance of futuribles are based on this information within the generic table.

The synoptic difference between the futuribles F_p and F_q is defined as follows. Let F_p and F_q be two synopses of the futuribles and consider the values x_{ip_i} and x_{iq_i}, respectively, which a certain futures variable X_i has in these synopses. Let further define a difference relation $\delta_{pq}^{\,i}$ such that $\delta_{pq}^{\,i} = 0$, if $x_{ip_i}=x_{iq_i}$, and $\delta_{pq}^{\,i} = 1$ otherwise. Using this relation, a synoptic difference (vector) $\Delta(F_p, F_q)$ for the futuribles F_p and F_q is defined in (9):

(9).

Now we can use the number of components which are equal to 1 in the synoptic difference (9) to define the synoptic distance between the two futuribles. The synoptic distance indicates how many future variables there are in the futuribles, which differ in values from each other. The synoptic distance thus is an integer between 0 and K.

Formally, the synoptic distance, denoted by $d(F_p, F_q)$, can be defined with the help of the synoptic difference:

(10).

The synoptic distance (10) is a well-defined distance-type measure in the sense that it fulfills all the properties required for a distance measure:

(9) $\Delta (F_p, F_q) = (\delta_{pq}^{\,1}, \delta_{pq}^{\,2}, \ldots, \delta_{pq}^{\,K})\ ;\ p, q = 1, \ldots, N.$

(10) $d(F_p, F_q) = \Delta(F_p, F_q) \cdot \Delta(F_p, F_q) = \sum_{i=1}^{K} (\delta_{pq}^{\,i})^2 = \sum_{i=1}^{K} \delta_{pq}^{\,i}\ .$

(i) Non-negativity and reflexivity:
$d(F_p, F_q) \geq 0$;
$d(F_p, F_q) = 0$ if and only if $F_p = F_q$

(ii) Symmetry:
$d(F_p, F_q) = d(F_q, F_p)$

(iii) Triangle inequality:
$| d(F_p, F_r) - d(F_r, F_q) | \leq d(F_p, F_q) \leq d(F_p, F_r) + d(F_r, F_q)$.

The properties (i) and (ii) are direct consequences from the definition (10), proof of the validity of the triangle inequality is also straightforward but is omitted here. On the other hand, the synoptic distance does not possess such common properties of a relation as additivity and transitivity. The synoptic distance is in a sense analogical to the L_1-norm (absolute value norm) in the Euclidian space.

C-close futuribles

Futuribles at the distance C between each other are said to be C-close. When the futuribles are 1-close they differ only by one value element of one variable, and when they are C-close the number of the variables with different values is C.

Let us choose some of the futuribles of the futures space to represent the present or a hypothetical present. The number of other futuribles at a given distance from this centre point can easily be calculated. Obviously, the synoptic distance from the centre to itself is zero and the distance to the most remote futuribles within the "horizon" is given by the extension number K of the futures manifold. All futuribles are distributed in the orbits of the space at a distance C from the center so that $0 \leq C \leq K$.

The number of the 1-close futuribles around the center is obviously

(11).

i.e. the total number (M) of the cells in the generic table minus the number (K) of the futures variables (or rows in the table).

For the 2-close futuribles we get:

(12).

The last sum expression is used as a shorthand version of the preceding double sum.

The general formula for the number of the C-close futuribles ($0 \leq C \leq K$) can be shown to be

(13).

where again the last sum expression is used as a shortened notation for the multiple product sum expression.

For the number of the most remote, K-close futuribles at the horizon, one gets the factorial form

(14) $N_K = (n_1 - 1)(n_2 - 1) \ldots (n_K - 1) = \prod_{i=1}^{K} (n_i - 1)$.

The C-close futuribles are located in a same orbit, but they are Z-close to each other, where Z is not a constant but obtains different values from zero to $2C$ or K taking the smaller of the two. This reflects the non-transitive character of the synoptic distance and C-closeness relation: the relation is reflexive and symmetric, but it is not transitive for reasons stemming from the synoptic difference. The closeness relation is also non-additive, but it still

(11) $N_1 = (n_1 - 1) + (n_2 - 1) + \ldots + (n_K - 1) = \sum_{i=1}^{K} (n_i - 1) = \sum_{i=1}^{K} n_i - K = M - K$,

(12) $N_2 = (n_1 - 1)(n_2 - 1) + (n_1 - 1)(n_3 - 1) + \ldots + (n_{K-1} - 1)(n_K - 1)$

$$= \sum_{i=1}^{K-1} (n_i - 1) \sum_{j=i+1}^{K} (n_j - 1) = \sum_{j>i} (n_i - 1)(n_j - 1) .$$

(13) $N_C = \sum_{i_1=1}^{K-C+1} (n_{i_1} - 1) \sum_{i_2=i_1+1}^{K-C+2} (n_{i_2} - 1) \ldots \sum_{i_{C-1}=i_{C-2}+1}^{K-1} (n_{i_{C-1}} - 1) \sum_{i_C=i_{C-1}+1}^{K} (n_{i_C} - 1)$

$$= \sum_{i_1 < i_2 < \ldots < i_{C-1} < i_C} (n_{i_1} - 1)(n_{i_2} - 1) \ldots (n_{i_{C-1}} - 1)(n_{i_C} - 1) ,$$

obeys the triangular equation as the synoptic distance does (see property (iii) before).

The distance (or closeness) of any two futuribles F_p and F_q, denoted by C_{pq}, can formally be expressed using the Delta tables as follows

(15) $$C_{pq} = K - \sum_{i=1}^{K} D^p{}_i \cdot D^q{}_i \,,$$

where the general (i^{th}) term in the sum expression is the scalar product of the i^{th} row vectors of the tables D^p and D^q, respectively, and it reveals whether the ith value elements in the two futuribles F_p and F_q are the same (the scalar product equals to one) or not (the scalar product is zero). The complete distribution of distances between any two futuribles is determined using the generalized products of the Delta tables, cf. definition (8) above, and their scalar products:

(16).

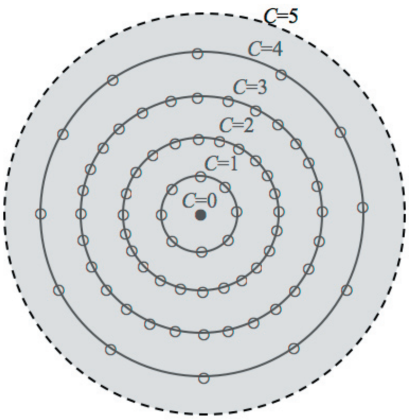
In the last expression of Formula (16), $\boldsymbol{K}$ is a $N \times N$-matrix having K as all of its elements and $(\boldsymbol{D} \circ \boldsymbol{D})^2$ denotes the $N \times N$ -matrix of the elements $(D^p \circ D^q)^2$.

The futures space defined by the generic table is most symmetric. Each synopsis is surrounded by equal number of other synopses at the same distance from it. Metaphorically speaking, the "cosmos" of the futures space looks similar in every "direction" and similar from every synopsis. The symmetry may be broken, however, by bringing the past, present, and future into the "cosmos". The present is a centre futurible in an egocentric mapping of the futures space; the centre may also represent a hypothetical present instead of one just being experienced. Figure 4 gives a graphical illustration of the futures space of the generic table in Figure 2 and the distribution of the futuribles in C-close orbits of different distances, $0 \leq C \leq K$. The outermost ($C = K$) orbit remains empty, due to the fact that the fifth variable of the table is a futures constant.

The C-close futuribles are different qualitatively and semantically, which is of no concern to the closeness measure. Semantically, the differences may mean anything from crucial or epoch making change to a small shift of orientation or change of resolution of an issue. The theory of futuribles does not concern the semantics but only syntax of the futures mapping.

As observed earlier, the distance between the futuribles is not additive or transitive in general. However, it is possible to find sub-sets of futuribles in the futures space where the closeness

(16) $$(C_{pq})_{N \times N} = \left(K - (D^p \circ D^q) \cdot (D^p \circ D^q)\right)_{N \times N} = \left(K - (D^p \circ D^q)^2 = \boldsymbol{K} - (\boldsymbol{D} \circ \boldsymbol{D})^2 \,.$$



Distribution of futuribles according to the distance from a given futurible	
C	N_C
0	1
1	8
2	23
3	28
4	12
5	0
Total	72

Figure 4. The futures space of the futuribles spanned by the generic table in Figure 2.

relation is both additive and transitive. By additivity and transitivity is meant that the triangular relation is an equation between the distances of any three futuribles F_p, F_q, F_r, i.e.

(17) $C_{pq} = C_{pr} + C_{rq}$.

When additivity and transitivity are applied to a directed net of successive futuribles and when they hold on triples of futuribles which immediately follow each other, we call them local additivity and transitivity. Another special form of additivity and transitivity which can be defined on a futures space is called egocentric additivity and egocentric transitivity, respectively. In these relations one of the three futuribles, F_{p_0} is fixed ("choice of the origin") and the triangular relation refers (the equality form) to this center futurible: $C_{p_0q} = C_{p_0r} + C_{rq}$. Egocentrically additive and transitive sub-spaces are at the base of scenario approaches, and there is an algorithmic way to determine them based on the $N \times N$ matrix (C_{pq}). The locally additive and transitive sub-spaces are analogical to those of the one-dimensional sub-spaces of higher-dimensional spaces in the case of Euclidian metrics.

Transformations of the futures manifold

Partitioning the futures space

A futures variable can be used as a parameter, as mentioned earlier. With the separate values of the parameter the futures manifold can be partitioned into separate "hemispheres" of the manifolds. With the two values of the variable X_1, for instance, the generic table of the futures manifold in Figure 2 can be partitioned into two exclusive sub-manifolds as, say, a "Northern" and a "Southern" hemisphere of the futures space. In Figure 5 the manifold of Figure 2 is partitioned into two. As compared to the original futures manifold, it is to be noted, that the extension of the sub-manifolds has decreased to four, and the constant value of the variable X_5, which is the same in all 72 futuribles, is depicted as a common background for both hemispheres.

Figure 6 gives a graphical illustration of the two hemispheres of sub-manifolds presented in the generic tables of Figure 5. As in Figure 4, the futuribles are distributed on C-close orbits around a center for different values of $0 \le C \le K$. Because of the common futures background variable X_5, the dimension of both sub-manifolds is four ($K = 4$). The outermost orbits ($C = 4$) of the hemispheres are empty. This is because the first variable X_1 has the role of a partitioning parameter and its value element in each hemisphere becomes in turn a futures constant (x_{11} for the first hemisphere and x_{12} for the second). The numbers of futuribles in different orbits are $N_0 = 1$, $N_1 = 7$,

Futures variable	Generic table				# cells
X_1	x_{11}				1
X_2	x_{21}	x_{22}	x_{23}	x_{24}	4
X_3	x_{31}	x_{32}	x_{33}		3
X_4	x_{41}	x_{42}	x_{43}		3

$X_5 = x_5$, **constant futures background**

K=4 M=11 $\bar{n}$ =2.75

$X_1 = x_{11}$ **sub-manifold**

Futures variable	Generic table				# cells
X_1			x_{12}		1
X_2	x_{21}	x_{22}	x_{23}	x_{24}	4
X_3	x_{31}	x_{32}	x_{33}		3
X_4	x_{41}	x_{42}	x_{43}		3

$X_5 = x_5$, **constant futures background**

K=4 M=11 $\bar{n}$ =2.75

$X_1 = x_{12}$ **sub-manifold**

Figure 5. Partitioned futures manifolds with the variable X_1 as the parameter and the variable X_5 as a constant futures background

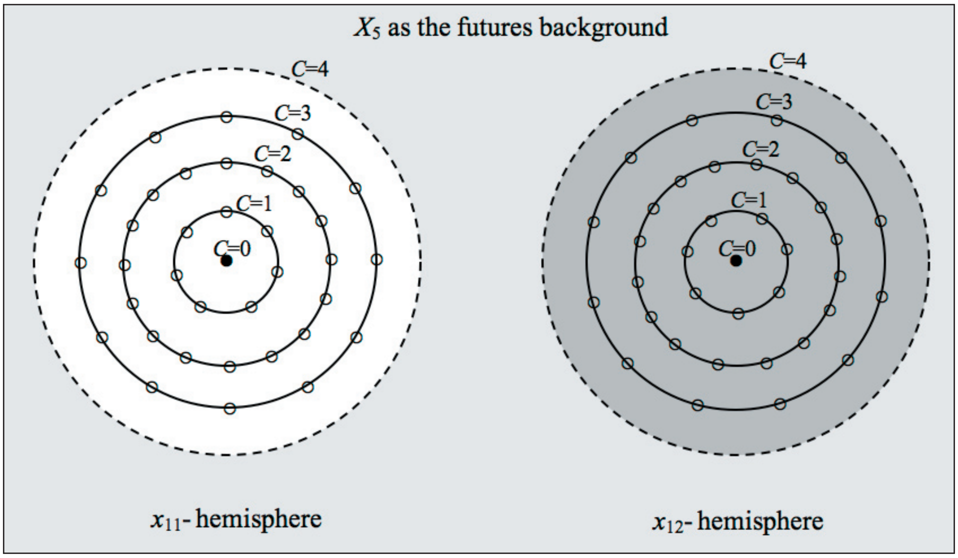


Figure 6. Illustration of the partitioning of the futures manifold into two hemispheres

N_2 = 16, N_3 = 12 and N_4 = 0 for both hemispheres.

Other transformations

Futures manifold as a map may be more or less expressive in relation to the futures issues envisioned in two ways. Maps may be needed to show deformation of societies in a more or less coarse way. This capability will be achieved with transformations of the preliminary generic table in futures mapping. There are two options to do the transformations and they may also be combined.

First, the value domain of some variable may be extended by adding new value elements for instance by splitting some previous value element into more detailed parts, or the domain can be made coarser by removing some value elements. The number of the futures variables, i.e. the issues of the future, remains fixed in this transformation and only the variety of the value options of one or more variables are changed. The transformations may be relevant in order to change the coarseness of resolution of some issues or for some other purpose. Using the map analogy, the transformations can be interpreted as a choice of the scale.

By letting the domains of the variables be variant but keeping the number of the variables fixed we attain a generalization of the futures space concept called a futures galaxy. A set of futures spaces with the same variable set is called a futures galaxy. The dimension of the galaxy is the same as the dimension of its future spaces, i.e. the number of the variables (K). It is worth noting that in the galactic transformation the synoptic distance remains defined.

If the galaxy consists of the future spaces $\boldsymbol{F}_1$, $\boldsymbol{F}_2$,..., $\boldsymbol{F}_P$ of K-dimension, where each $\boldsymbol{F}_p$, p=1,2,...,P is a set of the futuribles F_{pi}, i = 1, ... , N_p, the galaxy can be formally denoted by (18).

Another transformation of a generic table is more profound than that of the galactic transformation. In that transformation new variables are added to the table, i.e. the futures space is extended by dimension, or vice versa some variable is deleted from it whereby the futures space is contracted.

$$(18)\quad \boldsymbol{\Phi} = \boldsymbol{F}_1 \cup \boldsymbol{F}_2 \cup ... \cup \boldsymbol{F}_P = \bigcup_{p=1}^{P} \boldsymbol{F}_P = \bigcup_{p=1}^{P} \bigcup_{i=1}^{N_p} \{F_{pi}\}\ .$$

1. Demography	2. Technology/ Organisation	3. Culture/ Values	4. Globalisation	5. Macro economic policies (EMU)	6. Industrial policies	7. Social and employment policies	8. International regulations	9. European integration	10. Public actors	11. Trade unions	12. NGOs	13. Transnational corporations
Low population growth, medium participation growth	No major breakthrough. Downsizing. Continuing de-specialisation of Europe in high-tech	Increasing individualism. Fear of the future	Globalisation continuing, sectoral resistances, local difficulties	Broad EMU with limited coordination and no major tensions	"Horizontal" policies (competitiveness approach)	Continuing "decremental" adjustment of social protection	Mixed strength of institutions	Broad enlargement, deep integration	Governments constrained by interdependence and lack of consensus	Continuing decline. Persistence in protected sectors	Not significant economic role	TNCs increasingly important
Low population growth, high participation growth, openness to emigration	No major breakthrough. Increasing dualism. Increasing de-specialisation of Europe in high-tech	Strongly increasing individualism. Social and geographical segregation. Power of lobbies	Globalisation accelerating. "Borderless world"	Broad EMU with limited coordination and major tensions.	Acceleration of deregulation and privatisation	Strong labour market deregulation. Residual welfare state	Mixed strength of institutions. Increasing regionalism	Broad enlargement, shallow integration	Downsizing of government	Terminal decline	Significant economic role	Declining corporative advantage of TNCs (multinational SMEs)
Low population growth, low participation growth, closure to emigration	Major breakthrough. Europe innovating and/or catching up	Renaissance of social/ecological awareness. Regions/localities experiments	Globalisation slowing down, trade conflicts, regional blocks	Broad EMU with strong coordination.	"New" industrial policies (focus on users)	Strong resistance against welfare state reform	Weak institutions. Reversal of liberalisation	Narrow enlargement, deep integration	Institutional renewal	Decline reversal (new corporatism)	Very significant economic role (taking over welfare state)	Political reaction against TNCs
	Major breakthrough. Increasing technologically induced inequality. Europe catching up	Revolt of the bottom-half against globalisation	Global crisis	Failure of EMU	"Mercantilistic" industrial policies	Radical reform of welfare state: universalism and individual incentives	Strong global institutions (economic security council)	Failure of enlargement	Paralysis			
	Major breakthrough. Increasing technologically induced inequality. Europe falling behind											

Figure 7.A thirteen-dimensional extension of the five-dimensional futures space of gure 3 (source: Scenarios Europe 2010)

The synoptic distance is no longer defined between the futuribles of the transformed and the primary galaxy. Each transformed generic table of the second kind defines a futures galaxy of its own extension. The infinite set of the futures galaxies of different extension is called a futures multiverse.

The futures manifold design in Figure 7 was used recently in an EU-study[14] and it illustrates the futurible, futures space and futures multiverse concept. The futures space in Figure 7 is a 13-dimensional extension of the five-dimensional space presented in Figure 3. The new variables are non-shaded and the primary five variables shaded. The set of the darker-shaded value elements show the "Laissez faire" futurible in the primary space. For layout reasons the generic table of the extended space is again presented in the transposed form.

Histories and scenarios in the futures space

Future as a process

As stated earlier the future is not a state or an entity but rather an unfolding process which has been going on in the past and is continuing through the present. A study of the known and unknown forces and dynamics which drive the process belongs to the phenomenology of futures studies and not to the present syntactical study. The theory of futuribles is, however, a framework where in the trace of the process can be made visible so to speak. The process within the framework of the futures manifold is a directed digraph of successive futuribles going through a hypothetical present. A digraph of the futuribles leading to the present from the past represents correspondingly a history course. The present is a futurible breaking the symmetry of the manifold. We omit the formal presentation here and illustrate the process view by a digraph of the history and future course on the futurible map in Figure 8. In the figure it is assumed that the course goes via 1-close successive futuribles where the sense of "successiveness" comes from the semantics of the issues or from the phenomenological dynamics.

The number of the different courses of the future originating from a hypot-

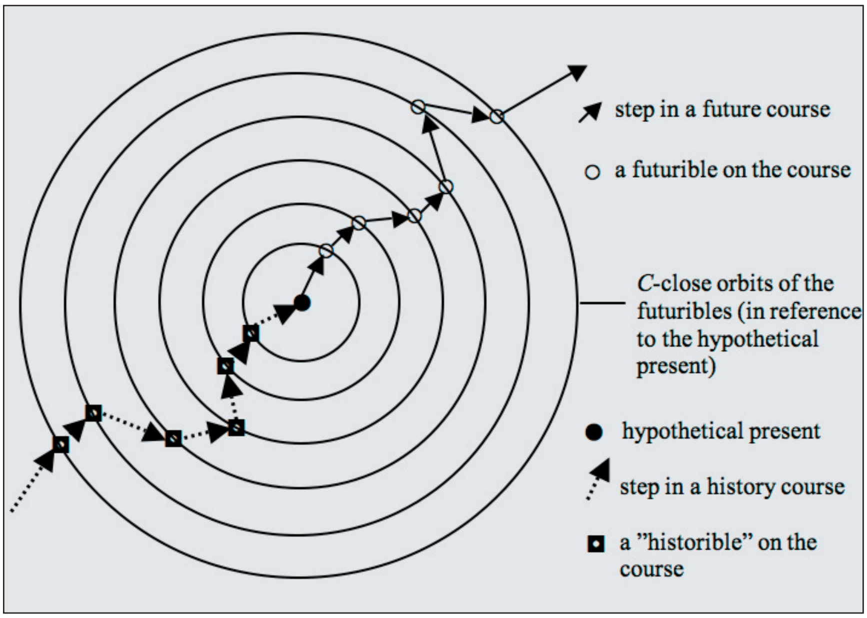


Figure 8. A digraph of a history course and a future course via a hypothetical presen

hetical present depends on the expressiveness of the manifold and on the other hand on the assumed dynamics and constraints of the process.

Systemic dynamics of the process of the future

A few remarks will be made about the dynamics of future unfolding. If we do not have any pre-understanding of it, we may assume that the process is a random walk process from one futurible to the next with plain disorder of randomness as the law. This is, however, hardly a satisfactory point of departure for a futures study. By breaking the symmetry with an introduction the present as a special point, we also assume the past and present somehow conditions the unfolding of the future. It seems reasonable to assume that a feasible future course is a descendant of the present. Furthermore it is obvious that the process of future cannot bring about anything against the laws of nature which thus constrains the feasibility of the futurible chain and the choice of one after the other.

It might further be unrealistic to assume that a feasible course of the future would consist of a repetition of one and the same futurible, neither would a course returning cyclically back to some earlier futurible match well with our experience. The process of the future is irreversible. There are non-linear attractor dynamics which are interesting to think about as a futures process. An attractor means a bounded set of futuribles which the course of successive chains of futuribles may asymptotically approach from different origins of the course. The character of the attractor may be for instance a constant fixed point futurible or a set of cyclically interchanging futuribles. Today's Western political drive toward capitalism, democracy and individual human rights may be seen as universal attractors of human development. But an attractor may also be a set of chaotically changing futuribles within a bounded set. And non-linear dynamics may bring along unexpected bifurcations from one type of a future to another attractor type,

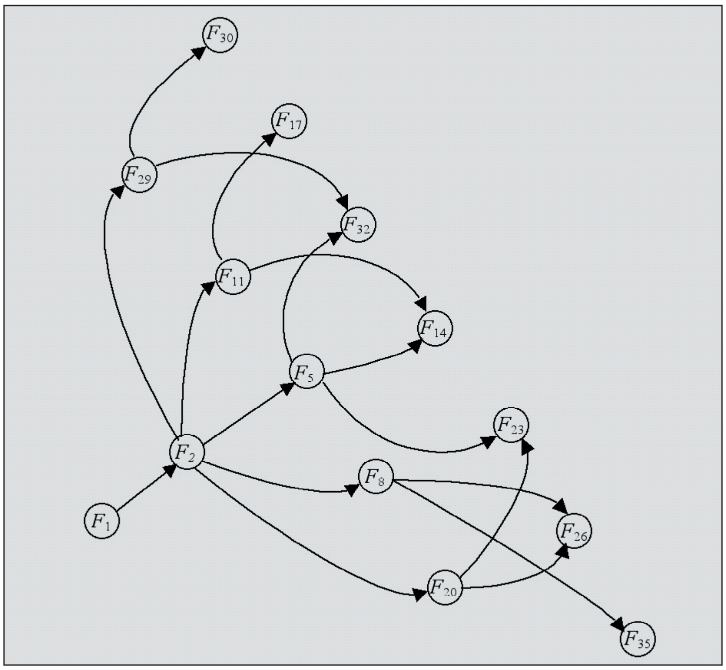


Figure 9. Egocentrically transitive futures digraph with multiple scenarios from a hypothetical present

and in addition to attractors also a complete disorder may be a possible course.

Knowing the dynamics of the process requires knowing its kinetic characteristics. Kinetics determines which futurible succeeds when the preceding ones are given. Kinetics determines how the preceding futuribles condition the next to follow. Social kinetic conditioning means that a futurible does not only carry information about the prevailing state but also about how the unfolding will take place.

Deliberate intervention

Even if we understand some of the systemic dynamics of unfolding and can present it explicitly as a dynamic system, much of the dynamics will always remain beyond our knowledge and comprehension. This makes prediction a difficult task in any accurate sense. Chaos dynamics may also become a temporary reality that makes prediction in the longer run impossible even when the short run prediction is possible. However, future's unfolding is considered to be at the reach of human interventions and free will to some extent, too in futures studies. A sample of the vast literature of strategic management exemplifies this[16]. It is necessary that the syntactical theory of futuribles should also allow presenting human intervention and choices in the map of the future. For this purpose we take into use the egocentrically transitive sub-space defined earlier.

Figure 9 represents one such sub-space taken apart from the futures space in Figure 4. The sub-space is directional from and to a futurible of the hypothetical present. There are several sub-spaces possible to choose from fig.4, only one of them (F_1) presented in the figure. There are in general futuribles at different distances from the present, cf. the orbits at distances C = 1, 2, 3, and 4. Between the triplets of the consecutive futuribles which are connected with arrows, the egocentric transitivity condition holds. There are several routes or futures courses to the futuribles most remote from the present.

Scenario is one of the basic concepts in futures studies It is used in somewhat different meanings, but it always refers to alternatives of the future. Multiple scenarios and a fan of futuribles are almost synonyms. Often a scenario is used to mean the same as a futurible, i.e. some point in Figure 9, e.g. F_{14}. Sometimes the scenario approach considers a futures course to the targeted end point from the present, e.g. the route $F_1 \rightarrow F_2 \rightarrow F_5 \rightarrow F_{14}$ or $F_1 \rightarrow F_2 \rightarrow F_{11} \rightarrow F_{14}$ to the end point F_{14}. As illustrated in the figure there are usually several alternative routes to a targeted point, i.e. there are several scenarios to consider.

It is then natural to compare not only the end points but also the alternative courses with each other assuming that one has foreknowledge about what it would mean to take this route or another. Some course may be regarded as more probable than others, another may be seen as more desirable and yet another one undesirable or threatening. This kind of valuing belongs to the semantics of futures study.

Concluding remarks

Knowing about the future has a different canon of legitimation than that of knowing the past and present, it can be regarded as more general in the scientific sense because of the intentional characteristic of knowledge of the future. These ontological premises of the futures knowledge was discussed based on some classics of the futures studies. A logical construction based on a morphological setting called the generic table of the futures manifold was developed and a syntactic theory of futuribles was presented. The concept of futures space, galaxy and futures multiverse has been derived and synoptic difference and distance between futuribles in the futures space is mathematically formalized. Local and egocentric transitivity of the distance measure formulated gives the consistent logic of scenarios and futures courses and an explanation to history courses of “historibles” as well. The formalism developed in this paper was firstly introduced in a recent article by the authors.[17] The present paper, however, is a more comprehensive and deeper analysis on the subject. It also links the analysis closely to the general discourse of futures studies.

Notes

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iii We are grateful to Dr. Eleonora Barbieri Masini for invaluable information based on her initial work on the concept of the future (Futurum-futura) in 16th century Latin mainly in Jesuits' texts starting from de Molina and advancing through analysis of later texts

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