LECTURE

3

Systems Identification

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LECTURE 3 - OVERVIEW

Premises for system identification

Supporting theories

WHAT IS IDENTIFICATION?

Relation between the real object and its model

- process of matching (identifying) model with its real object

Two possibilities:

- Matching the model with the object
- Matching the object with the model

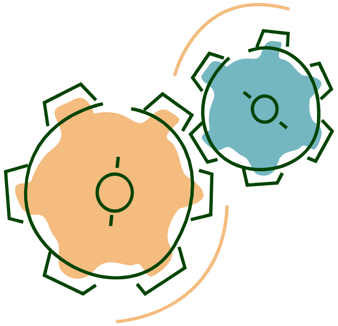
IDENTIFICATION IN SYSTEM ENGINEERING

Construction and creation of models in order to be able to

- Repeatedly
- Reliably

create new objects in the real world

Creation of **functional** and **reliable** model precedes its practical realization.



WHAT CONDITIONS MUST BE FULFILLED?

SYSTEM IDENTIFICATION

Basic steps as described in system analysis:

1. Choice of the level of distinguish of the whole.
2. Choice of Systems Elements (nomination or generation; it is true for the near / structured neighbourhood as well)
3. Allocation of functions to the elements.
4. Definition of coupled pairs of elements, definition of Systems relations, definition of Systems structure, introduction of metrics.
5. Identification of alternative processes – i.e. area of adaptability of the System.
6. Specification of the conditions which are to be fulfilled to activate the processes from the neighbourhood .
7. Stating and utilisation of the rules for identification of strong functions and compactness.
8. Identity.
9. Competence
10. Ethics

ARE THESE STEPS ALWAYS FEASIBLE?

PREMISES FOR SYSTEM IDENTIFICATION

It is necessary to recognize (on the chosen level of distinguish):

- Particular presence of objects
- Goals those objects are pursuing
- Different meaning of system characteristics in relation to their presence in particular place
- Different meaningfulness, usefulness of the objects (not goals, goals are internal parameter, usefulness external – evaluated by the surroundings)
- Availability of capabilities and tools for recognition of particular presence

SUPPORTING THEORIES

The premises can be assessed using lot of supporting theories and fields:

- Production functions theory
- Theory of effects
- Theory dealing with the knowledge phenomenon
- Engineering approaches to the artificial intelligence tasks

PRODUCTION FUNCTION ANALYSIS

In general, **production function specifies output of the system** (in economy output of a company, industry, national economy)

In systems engineering it is based on the identification of parts

It is assignment of corresponding functions to the elements:

$$a_i := f(x) \rightarrow y,$$

$$\text{or } \forall\, a_i \in \boldsymbol{A}\ \exists\, y_j = f_j(x_{1\ldots n}),\ f_j \in \boldsymbol{F}).$$

Where

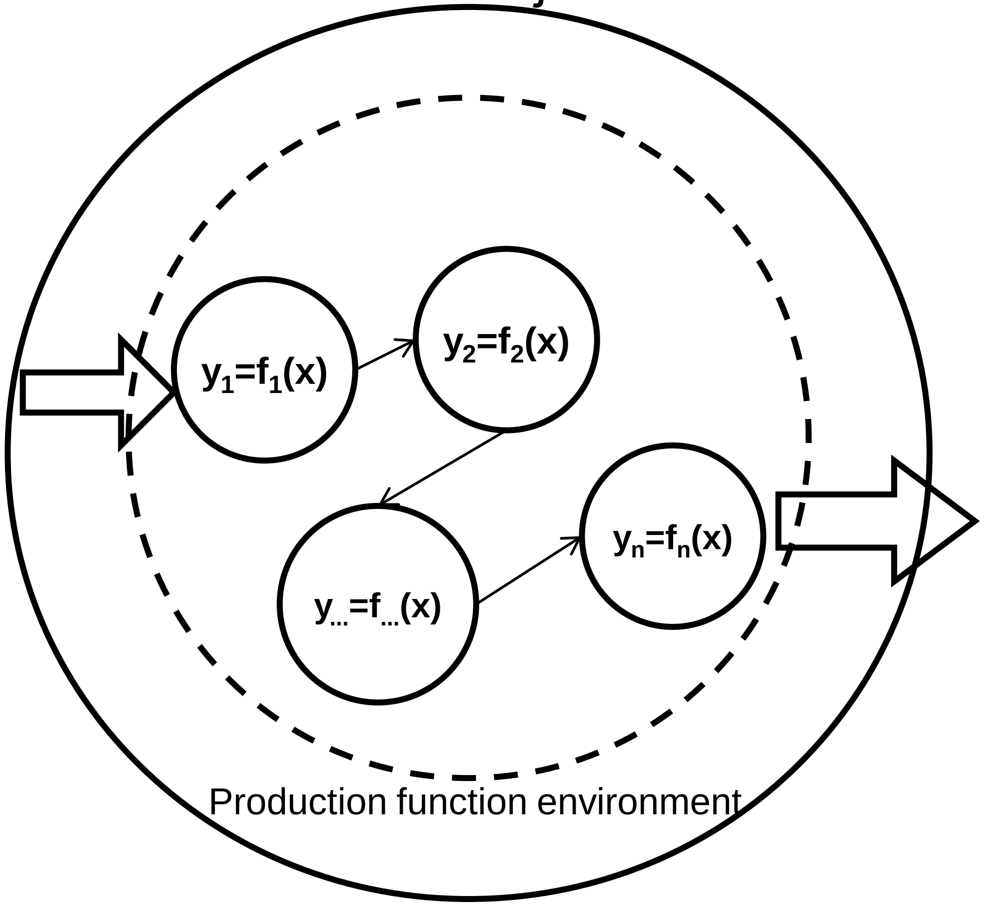
f is the function describing the capability of the system element

x are arguments of the function, i.e. inputs in the element

y is resulting value of the element capability

PRODUCTION FUNCTION ANALYSIS

Sequence of this production functions creates processes of the object → „the production function“ of an object



RESULTS OF THE PRODUCTION FUNCTION ANALYSIS

In the production function theory there are two basic attitudes for the identification of objects:

I. Based on the arguments x and output y
i.e.. „wealth“ - set of resources (S)
S can be divided

- based on the material content
  - mineral sources,
  - material sources,
  - energy,
  - information
  - social sources (such as education, environment, health, etc.)
- Based on the distribution of resources:
  - Individual
  - Group
  - State

RESULTS OF THE PRODUCTION FUNCTION ANALYSIS

II. Based on the function f itself

- formal shape of the function (tools of numerical mathematic) – e.g. Deterministic, stochastic, discrete, ...
- Purpose and goal of the function
  - reproduction $x \dashrightarrow y = x$
  - transformation $x \dashrightarrow y \neq x$
  - development $x \dashrightarrow y > x$
  - consumption $x \dashrightarrow y < x$
- capacity of the carrier of the function
- space where the function is effective
  - local impacts,
  - binary cooperation,
  - linear cooperation= processes function,
  - In the space of goal behaviour – function forming the purpose
  - In the space of survival – forming the meaning of existence
- Technology level of production function (see further)

TECHNOLOGY LEVELS OF PRODUCTION FUNCTIONS

basic technological level of production function:

→TPF

$$TPF := f(\mathbf{S/D}) \rightarrow \mathbf{S'/D'}$$

where *f* is a formula for production function;

- ***S*** is set of resources („wealth“);
- ***D*** is distribution of „wealth“ among owners
- ***S'*** is new quality of resources („wealth“) after application of *f*;
- ***D'*** is new distribution of „wealth“ as a result of application of *f*.

ECONOMIC AND STANDARDIZED PRODUCTION FUNCTION

If the result of TPF is: ***S'*** = ***S***, but ***D'*** ≠ ***D***; or ***S'*** ≠ ***S*** and ***D'*** = ***D***,

→ exchange of either wealth or ownership.

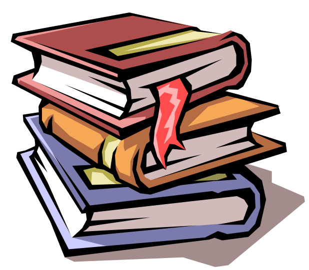
The exchange is called **economic production function**:

→EPF

$$EPF := f'(\mathbf{S(D), C(D)}) \rightarrow \mathbf{S'(D), C'(D')}$$

where ***C***, resp. ***C'*** is a price as a coefficient of an assignment of **D** to ***S***.

If it reaches the non-compliance between ***D*** and ***S*** and ***C***, it is needed to input criteria's, norms, preferences, standards, rules, laws
→ **standardized** (legislative) **production function**:



→NPF

$$NPF := f''(\mathbf{S(D), C(D), N}) \rightarrow \mathbf{S'(D'), C'(D'), N'}$$

where ***N***, resp. ***N'*** contents these criteria's, norms, preferences, standards, rules, laws etc.

INFORMATIC AND AUTOMATED PRODUCTION FUNCTION

To be able to assess the impact of the standards, identify the feedbacks of these changes, ability to transfer and use information and knowledge is necessary → next level is **informatic production function**:

→IPF

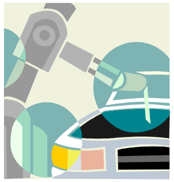
$$IPF := f'''(\mathbf{S(D), C(D), N, I}) \rightarrow \mathbf{S'(D'), C'(D'), N', I'}$$

where ***I***, resp. ***I'*** is a set of knowledge on the environment and feedback impacts.

(usage of information influencing the production function – e.g. marketing)

At the today's time of **information explosion** is necessary to transfer a processing of information, knowledge’s to **more powerful carriers**, to increase a performance of information and knowledge systems; it means an **automated production function**:

→APF



$$APF := f''''(\mathbf{S(D), C(D), N, I, A}) \rightarrow \mathbf{S'(D'), C'(D'), N', I', A'}$$

where ***A*** and ***A'*** represent different performance of carriers of previous levels of production functions.

ETHICAL PRODUCTION FUNCTION

Also in the production function area it is possible to evaluate the sense , legitimacy, goal quality, ethics of production function levels:

ethic production function:

→**MPF**

$$MPF := f''''' M(TPF, EPF, NPF, IPF, APF) \rightarrow$$

$$M'(TPF, EPF, NPF, IPF, APF) \rightarrow (TPF', EPF', NPF', IPF', APF'),$$

where ***M*** is a set of abilities to evaluate production functions;

M' are abilities **to reassess** the former production functions;

' means revised production functions of lower levels.

The difference of the previous evaluation and new evaluation (M-M‘) represents **social experience**.

THEORY OF EFFECTS DIMENSION

Presence of objects can be distinguished by the goals they are achieving

Goals are measurable and can be described by certain effect criteria of production function operation

Basis for the effect criteria is the relationship between sources (S) and products (P) alias wealth x subject of production functions

presumably desirable P >= S (a principle of *minimax* (min S for max P) – achieving maximal output for minimal input – for minimum resources achieving maximal results)

The minimax is influenced by two factors:

- Structure (different combinations of S and P)
- Space

STRUCTURE OF SOURCES AND PRODUCTS (MINIMAX)

cost structure

only S (sources) are taken into account

The minimax criterion is achieved
by the simple aim to minimize the sources

Types of cost structure (according to the production function):

- TPF – technological – all activities (production, economic, culture) are conducted with minimal inputs
- EPF – economic – goal is to carry out the lowest amount of exchange
- NPF – standardized – standards created with minimal inputs (personal, administrative)
- IPF – information – goal is minimal price for information, which can lead to preferring not-knowing
- APF minimal costs for adjusting the automata to the environment
- MPF – goal to give as less as possible, do not change – results in compromises, ...

„poor people attitude“

STRUCTURE OF SOURCES AND PRODUCTS

profit structure

Emphasizing Product without respect to Sources

„rich people attitude“

Examples of types according to the production functions

- NPF – standardized – in order to achieve measurability with other objects goal to increase the administrational capacities, to standardized all activities, etc.
- IPF – information – goal to have complete information – risk of not using it
- APF – increasing user comfort regardless the cost
- MPF – expansion, aggressivity, „consumption way of life“

STRUCTURE OF SOURCES AND PRODUCTS

cost-profit structure

The most developed structure, taking into account turnover, optimization, economic return, etc. → efficient, reasonable

reproduction structure

Requires also the renewability of sources, sustainability, etc.

-Different programs of maintenance, renovation, modernizing of resources.

not only P >= S, but the part or P, that becomes S for the next step, fulfils $S_i <= S_{i+1}$

Examples of types of reproduction structure (according to the production function):

- TPF – renewal of technologic infrastructure
- EPF – economic – stable position in the market
- NPF – standardized – ensuring legal continuity
- IPF – information – keeping information level about both own environment and surroundings
- APF – automatized – increase of activities thanks to automation
- MPF – keeping education and communication functions

STRUCTURE OF SOURCES AND PRODUCTS

<u>transformation</u> structure

Enlarging the reproduction structure with the condition of

$S' \rightarrow S_{ti} \neq S_{t0}$

relation between S_{ti} and S_{t0} as change of source structure in the next cycle

(structure of sources changes either derived from the effect in the other production functions, or as competitive ability of the environment)

<u>functional</u> structure

Does not work with sources and products but uses the shapes and course of production functions

The requirements on S and P are constructed retrospectively from the function with respect to the functionality and safety of activities

SPACE FOR PRODUCTION FUNCTION EFFECTS

corresponding with Euclidean space

Extent	explanation	example
point	local, selfish	effect of one company
vector	cooperation	supplier-customer effect between two companies
line	technology	effect of continuity of processing the sources S to the product P
network (area)	integration	interdisciplinary or multi-national cooperation
3D	expansion	Search for new space of development activities (e.g. exploitation of ocean, development of technologies in outer space)
4D (including time)	pragmatism	consideration the stability of the effect evaluation as a failure/success
social approach	selective approach to effect	differentiation of activities corresponding with particular social groups
global approach	ecosystem theory	sustainable development

SUMMARY OF PRODUCTION FUNCTION EFFECT EVALUATION

an interpretation of effects dimension as a table of **space x structure**

Effect are differentiated base on effect quality

superiority of space dimension over structure dimension

it also represents the practical achievability of the effect

(note: the numbers represent just the conception, do not take them as exact values!)

	cost structure	profit structure	cost-profit structure	reproduction structure	transformation structure	functional structure
point	1	2	3	4	5	6
vector	7	8	9	10	11	12
straight line	13	14	15	16	17	18
network	19	20	21	22	23	24
3D	25	26	27	28	29	30
4D	31	32	33	34	35	36
social	37	38	39	40	41	42
global	43	44	45	46	47	48

THEORY OF KNOWLEDGE

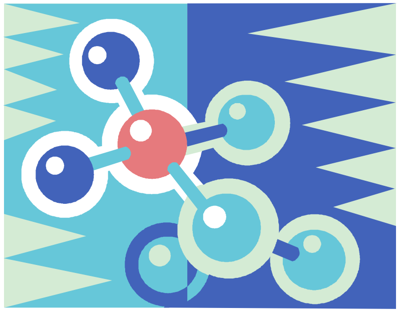
Knowledge theory – part of modern informatics

Significance of methods and techniques of model processing

The model is tool for control of the original

Informatic engineering is developing in three directions:

- Language constructs
- Technology process
- Model quality



INFORMATION ENGINEERING TRENDS

language constructs for creation of the model (of particular object)

- **definition of language**, or multilanguage or hyperlanguage;
- choice of **metric system** for the analysis of dimensions of the original;
  - metric of construction (bit, character, word, sentence, storage, tree, set, base);
  - Metric of values of a language construction (logical, numerical, text, graphics, linguistic);
- **Grammar analysis** for mutual translatability between models of originals,

phases of a technologic process of model processing:

- analysis of **data collection** phase;
- transfer of data, their **saving and selection**;
- **conversion** of metrics;
- **interpretation** and implementation of data back to an original;

quality of the model:

- according set of data **origin**, their **importance** (semantics), their **application** and their **level of pragmatic value.**

MODEL QUALITY – DATA TYPES

a. data types according their **origin**

- factual;
- derived;
- hypothetical;
- nomological (analogy with axioms, data generated from nature law).

b. data types according **semantics** (importance), differentiated based on the basic alphabet symbols (alias **syntactic language constructs)**

Basic symbol of the alphabet	semantics
bit	existence (yes/no) of the original
character	specification of a semantics of an unique element in the model of the original
word	semantics gets values of existing attributes
sentence	differentiation of concrete objects (analogy with data record)
storage, tree	differentiation of an order of objects in the certain environment
set	assemblage of objects with at least one the same attribute
base	assemblage of certain objects in the certain environment, a construction of the environment for an ordering of sets

MODEL QUALITY – DATA TYPES

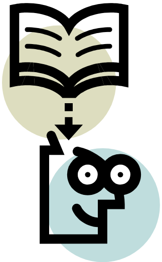
c. data types according their usage

- working data;
- data on changes;
- status data;
- archive data.

d. data types according the **level of importance of their pragmatic value**

- relationship between the elementary piece of knowledge and syntactic language construct
  - syntactical language construct → *simple, non-evaluated model of the original* → **data**
- relationship between data and their user, particular quality of data is increased by the value for their user.
  - data → *function of assessment of input data by their user*→ **information**
- Relationship among information or between data and information, derived knowledge, an information „anything“, what is not detectable as simply data, but that is generated from a combination of data and their subsequent information.
  - data × information → *function of combination (transitivity, deduction)* → **knowledge**

MODEL QUALITY – DATA TYPES



- relationship of information or knowledge with the effect, result of activated process (see theory of production functions or effect theory), this relation is extended by measurable quality of the result of using particular information - rate of responsibility, or rate of experience.
  - Information, knowledge × effects, results → *assessment of quality of the result knowledge* → **responsibility**
- relationship between information or knowledge and the existence of the object – amount of support (or service) of processes, an increasing of recognition about quality of usefulness of this information or knowledge, that is wisdom.
  - information, knowledge × processes at a system → *a rate of usefulness, a necessity of a result* → **wisdom**
- relationship between information, knowledge, responsibility or wisdom and any external system, any surroundings, rate of external support or receipt by surroundings, this is quality of something as a trust („...blind religion...“). For example it may be a political belief, religion, science faith, economy faith...
  - information, knowledge, responsibility, wisdom × surroundings → *justification of a result* → **faith**

BASIC HIERARCHY, CONCLUSION OF KNOWLEDGE THEORY

Basic hierarchy

- Functional – based on the functions of elements
- Power – based on the surroundings input, standards, orders, etc.

An integration of quality of data (data types etc.) and their pragmatic value and mutual hierarchy creates **knowledge system**

(not a system of knowledge - it is „only“ an ordering of separate knowledge, while knowledge system is complete system of connected data, information and knowledge between them with relationships with their surroundings as their users etc.)

THEORY OF ARTIFICIAL INTELIGENCE

ability of object identification in cybernetics viewpoint

ability to make a model of the original, to evaluate its attributes and to control alias to perform decisions

engineering approach to these abilities as certain **manifestation of an intelligence**:

- perception (completeness of perception, readiness of perception including readiness of transfer)
- reasoning (combination of perceptions to pieces of knowledge over original perceptions)
- action – „intelligent level“ (complexity of perceptions, usefulness of concluded results, readiness of application of these results)

THEORY OF ARTIFICIAL INTELIGENCE

tasks of artificial intelligence according the manifestation of intelligence

- Perception tasks – about identifying of images of originals, measuring, naming
- reasoning tasks– attitudes of how to solve the tasks
- action tasks – functions of events compared to changes of knowledge state space

a study of an artificial intelligence theory based on the subject of interest:

- mathematic theory (how to define, to describe, to articulate intelligent abilities of a machine)
- engineering of artificial intelligence (possible tasks, resolvable by a machine)
- robotics (a construction of this special machines)

ARTIFICIAL INTELLIGENCE TASKS

specific tasks of artificial intelligence (AI) based on the space dimensions:

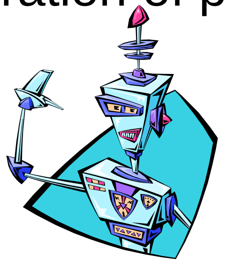
where is possible to use abilities of AI - in the diagnostic theory it is possible measuring of coverage of this space

- Theoretical coverage – all possible activities
- Actual coverage – performed activities
- Critical coverage – activities with failures

ARTIFICIAL INTELLIGENCE TASKS

Processes of AI manifestations:

- searching for optimal version
- experience - difference between planned and real result
- similarity – using e.g. cluster analysis
- adaptability - space for possible processes (reactions) to the outer inputs and events
- searching for space or goals in order to find new space for objects that is „without“ adaptability
- controlling of parallel processes
- solving with non-complete information - for example experience methods or fractal methods
- abstraction – leaving out less importance pieces of knowledge, risk management
- generalization – summing up or reducing or integration of pieces of knowledge
- making of hypothesis and their proofs
- prediction, including strategies



ARTIFICIAL INTELLIGENCE TASKS

- readiness of AI application
  - *interpretation distance* and a complexity of interpretation function between object and model
  - theory of signal levels (*first* level without translator, interpreter x *a second* level with translator, interpreter x *a one-and-half* level, when a translator or interpreter is a part of system, in its structure)

- reliability of AI process

measuring by uncertainty of results

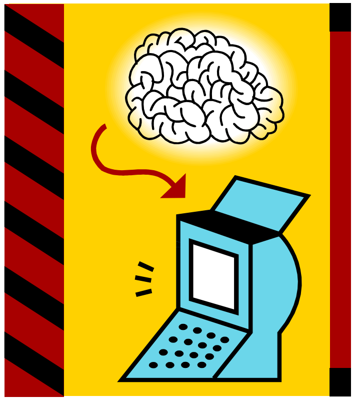
- *stochastically* in an existing of objects,
- *fuzzy* in its attributes,
- *associative* in relationships with their surroundings,
- *deterministic chaos* in predictability of further development

ARTIFICIAL INTELLIGENCE TASKS

- Ability to express, prove its intelligence

that is „education, qualification“ of a machine --> forms of manifestations

- *numerical* – is quantitative naming,
- *logical* – declarations about quality of attributes,
- *text* – language describing depending on a construction of language and its semantics and syntax,
- *abbreviation* – not applied in engineering



SUMMARY

Identification steps (with regards to everything mentioned before)

1. Choice of the level of distinguish of the whole.
2. Choice of Systems Elements (nomination or generation; it is true for the near / structured neighbourhood as well)
3. Allocation of functions to the elements.
4. Definition of coupled pairs of elements, definition of Systems joints, definition of Systems structure, introduction of metrics.
5. Identification of processes, including alternative processes – i.e. Area of adaptability of the System.
6. Specification of the conditions which are to be fulfilled to activate the processes from the neighbourhood .
7. Stating and utilisation of the rules for identification of strong functions and compactness.
8. Identity.
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Thank you for your attention

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