ISSN 2658-5014 (Print)
2019. № 1. С. 5–14
СИИТ
СИСТЕМНАЯ ИНЖЕНЕРИЯ И ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ
http://siit.ugatu.su

УДК 004.65

SOME PRACTICAL APPLICATIONS OF COGNITIVE INFO-COMMUNICATION

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Поступила в редакцию 18 декабря 2018 г.

Abstract. Some tools and methods of Cognitive Info-communication can be applied in waste material management, where the goal is to minimize real waste, applying re-use and re-make instead of recycle. Examples are given to show some problems and solutions, such as car sheet-metal parts, and orthosis as a medical application. 3D modeling and visualization assist the processes, as for example to support human decision making, and to create the tool paths to control Incremental Sheet Forming robots used to re-shape damaged or new parts.

Keywords: Damaged car; dangerous materials; control systems; 3D technology; graphical modelling; kilt model; natural capital; economic, ecologic issues.

INTRODUCTION

It is clear that the world is running out of energy, raw materials and water, and we will soon have shortages. The “soon” as time span may mean anything from 10-20 to 100 years, i.e. a short period in history. Sustainable development (or more often used the more modest, less positive expression sustainability) has to save as much materials, energy and water as possible. This study deals with the “last” phases of Product Life-Cycle Management (PLCM), see a little later on.. and material and energy saving are in focus. Material saving results in energy and water saving as well in most cases, as the production of new material needs more energy and water consumption, too. PLCM starts with the idea of a product, and lasts until complete dismissal. It has several steps and phases as detailed design, assembly design, etc., which are followed by part manufacturing, assembly, testing, diagnostics and operation, advertisement, service, maintenance, etc. Then finally disassembly and dismissal arrive, but dismissal can be substituted by re-cycling (e.g. melting the metals) or re-use (application of used parts). As a particular example in our study we examine the re-use possibilities (re-shape or re-make are often used with the same meaning) of damaged car body parts using 3D modeling and visualizations methods for finding buckles and fixing them by applying Incremental Sheet Forming.

We deal with several different, issues, including cognitive info-communications.

To assist the reader in orientation a short explanation is given on the structure of the paper and on the relationships between the main issues:

First some of the last steps of PLCM, namely dismantling/disassembly and re-use/recycling are discussed as important actors of sustainability. Dismantling is followed by tests to decide the worthiness of re-shaping (re-forming) of certain sheet-metal parts (e.g. car body parts). The decision making between any two steps of the procedure is rather sophisticated, both computer and human knowledge are taken into account, supported by data- and knowledge bases distributed worldwide, communicated via networks. Due to the human knowledge and the human’s role decision making is done using cognition (cognitive behaviour). The decision making process is supported by 3D visualisation, too.

The sheet-metal parts are separated into two categories: repairable and non-repairable. All second type pieces are sent to a shredder for re-cycling, the rest is repaired for re-use by a robotic set-up, using ISF technology. The robot and the technology are modelled and simulated by specific tools of the VirCA system, which assist in 3D operations of any model and of any real robot as well.

Finally the KILT model and the TYPUS metrics are introduced to calculate the economic value/loss of the planned and executed repair activities and other PLC steps.

THE MAIN GOAL: TO SAVE NATURAL RESOURCES

Material, water and energy shortages are the driving forces to deal with the recent topics, however now we underline that this study is born from the EU Directive 2000/53/EC according to which by 2015, the portion of each vehicle that should be recycled or reused has to increase to 95%, in other words only 5 percent may be lost. To avoid being too abstract in the following we use management of worn-out or crashed cars as an example.

EOL CARS: RUSE OF SHEET-METAL PARTS

Dis-disassembly of end of life cars (EOL cars) should have the following main steps ([1–3]).

1. Take special care of dangerous materials (oils, acids, lead in the battery, etc.). It is obligatory to start by taking them out.

2. Then a decision is needed whether to continue disassembly or not.

If we continued, all parts should be examined and classified as useful (very good, good, wrong and repairable) or useless (wrong and not repairable). This examination can be done either before or after taking the part apart. Classification should be continued until the last part has been dealt with, taking into account economic questions, too, as for example the market is full of a certain part or it is missing.

As disassembly is not a direct reverse assembly due to the fact that vehicles are used in a harsh environment, making smaller/bigger damages through everyday use, most external parts (e.g. screws and welds) become rusty, dirty and distorted.

This generally causes more complicated tools to use for disassembly than for assembly. It is true for the software support and for the hardware equipment as well.

In this study we deal only with a very restricted part of EOL cars, namely with sheet metal parts.

3. The first (mean: the next one) decision is whether to or not to disassemble the sheet metal parts. If a set of thickness measurements, or a visual examination say that the thickness is far from the requested value, or it is too much, or it is too rusty, it is better to finish the procedure and send the parts to the shredder.

If the thickness is acceptable and there are no specific visual problems

4. We have to examine the level of distortions and of all other damages and can decide to start or not to start de-welding. . De-welding means to cut (or de-weld) all welds and gain the original sheet metal parts, such as doors, wings, hood, etc.

Now we have a set of damaged metal parts.

5. We wish to re-gain the original shape of the damaged parts with a robotic ISF (Incremental Sheet Forming) system [in: Proc. NEW PROLAMAT Springer IFIP AICT 411 (pp. 239-253)4].

The system needs digital input, and processing often needs human intervention/assistance. The main task of our recent work is the re-use (re-shape) of the sheet-metal parts, and this re-use can be reached – among others – in the way given in the following parts of this paper.

HUMAN AND MACHINE DECISION MAKING

One can see from the previous descriptions that there are several automatic, semi-automatic and human decision points in the process. Most of the decisions must be supported by sophisticated sensory measurements (mainly computer vision, laser scanning) and by sophisticated software packages, and data- and knowledge bases, which are working on networks, and have intelligent solutions. do?" are decided, while the "why to do ?" was decided earlier. The above discussed problems and possibilities altogether (intelligent human and computer decisions, intelligent sensors and problem solving, robotics, robot-human cooperation, all on networks, etc.) led us towards a relatively new domain, called Cognitive Infocommunications (CogInfoCom, [5]).

CogInfoCom proposes a new and unified conceptual approach in which the process of merging is derived from the theoretically unified concept of different levels of cognitive capabilities co-existing in the information space (irrespective of whether they are natural or artificial capabilities, and whether they are individual capabilities or capabilities which emerge from a cloud of artificial and/or biological components). This derivation extends to various aspects of the merging, such as interactions and communication, as well as increasingly flexible interfacing between networks of living beings and artificial cognitive systems etc.

Cognitive Info-communications deals with the link between the research areas of info-communications and the cognitive sciences, necessary due to human involvement. CogInfoCom contacts the various engineering applications which have emerged as the synergic combination of these sciences. The primary goal of CogInfoCom is to provide a systematic view of how cognitive processes can co-evolve with info-communications devices so that the capabilities of the human brain may not only be extended through these devices, irrespective of geographical distance, but may also interact with the capabilities of any artificially cognitive system. This merging and extension of cognitive capabilities is targeted towards engineering applications in which artificial and/or natural cognitive systems are enabled to work together more effectively. The task of re-shaping sheet-metal parts of EOV (End of Life Vehicle) sounds technically simple, but as analysed it is very complex.

Now let us repeat the main steps with the decision points of sheet metal parts of worn out vehicles:

- dismantling,
- sheet metal parts' selection,
- repair (re-make, re-shape) by ISF with human assistance.

If we study the complete process several computer-, human- and joint decisions are necessary, and human assistance is needed during some technological steps, using several networked programs and data/knowledge sources all the time. Even the technology (ISF) may need human interventions. This set of computer technologies plus the human involvement directly leads to the field of CogInfoCom.

A PROPER VISION FOR THE HUMAN - 3D

The rapid development of graphical modelling tools made the accurate modelling of complex systems possible. More advanced models require more sophisticated rendering techniques, as well. Three-dimensional visualization can supply the most realistic feeling in a virtual environment.

As a consequence of the advanced 3D technology considering both input and output devices, there is higher need for creating 3D models.

Based on the latest research results of cognitive informatics [6] new communication methods between intelligent control systems or robots and human beings have been developed. Using these methods on the one hand we can control real robots via their virtual models applying motion sensors and other intelligent control devices, like voice recognition systems.

3D rendering today is available not only for special devices but for TV sets, for desktop and notebook computers, too. There are several methods of 3D representation, so let us have a brief look at some wide-spread techniques, especially at those that we used in our research. For details see [6] and [7].

Viewing side-by-side images on active or passive monitors [8] requires special software that puts the images together and either filters the image to the left and right eye, or controls the active 3D glasses that separate the images and cause 3D feeling.

THE TARGETS OF OUR EXPERIMENTS

In our research we have applied 3D visualization of our industrial robot and its environment that performs *Incremental Sheet Forming.* After completing the 3D models we have connected them to the real processes in order to control them interactively.

Incremental Sheet Forming (ISF) is a relatively cheap and fast 3D shaping procedure of metal or polymer sheets to make one-of-a-kind production, or rapid prototyping. These applications would be very expensive with the traditional pressing die-sheet-die structure, as die production takes a lot of time and energy.

ISF is based on a series of local plastic deformations, created by a round or flat forming tool with a spherical head which is mounted on a CNC machine or on an industrial robot. In recent years the process has been tested also on (heated) polymer sheets. In all cases the starting point of the process is the 3D CAD model of the requested sheet part, from which the tool path calculation (for manufacturing) is done by a CAM program. The CAD model may be the result of the "original" design, or may be acquired by scanning the part.

ISF doesn't require special, complicated, expensive equipment, because a simple tool moves over the surface of the sheet causing a highly limited deformation. Consequently a broad range of 3D profiles can be shaped by moving the tool along a properly calculated track. The advantage of ISF is the possibility of forming sheet material without dedicated dies, and to avoid huge pressing machines. This is particularly profitable for small batch or customized production [9]. Incremental Sheet Forming (ISF) can be divided into two groups, depending on the number of contact points between sheet, tool and die. We speak about Single Point Incremental Forming (SPIF) when one side of the part is supported by a faceplate (see fig. 1).

Fig. 1. Single Point Incremental Sheet Forming

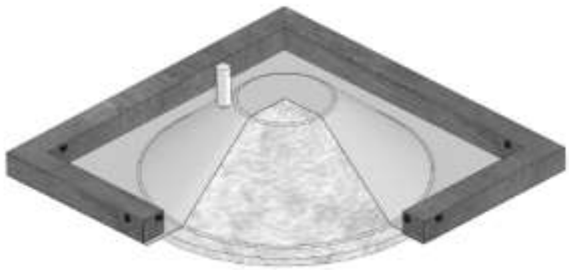

Fig. 2. Two Point Incremental Forming

The term Two Point Incremental Forming (TPIF) is used when a partial or full die is applied (see fig. 2). It is worth mentioning that a new and flexible variant with two synchronized forming tools can make almost arbitrary free form surfaces.

Thermoplastic materials can indeed be manufactured with ISF. Publications like dealing with the local heating of sheet metal parts in ISF, but none of them considers the possible application of it on thermoplastic materials. In [10] some preliminary experiments have been presented of SPIF of Polyethylene (PE) Sheets, but the optimization of the process still needs further research. The automotive, aeronautic and space industry [12] are interested in this new sheet forming technique, and experimental applications in medical aid manufacturing are also promising [12]. In the our robot laboratory of the Computer and (MTA SZTAKI) an industrial robot (Fanuc S-430iF) has been set up, which has 6 degrees of freedom. It is able to lift up 130 kg, and has a ~2.5 meters horizontal reach. With this industrial robot we made several experiments in ISF (see fig. 3) forming truncated or complete pyramids, cones and similar objects, in order to establish the optimal process parameters (like forming speed and force).

Repairing car body parts

Generally the most complicated decision in the case of sheet-metal parts is to assess the shape/form of all objects. There are many fields of this decision making process, and the most advanced possibility is 3D modelling and visualization to assist human decision. In several cases it is enough to have a look at the sheet-metal part to decide if it is worth repairing it.

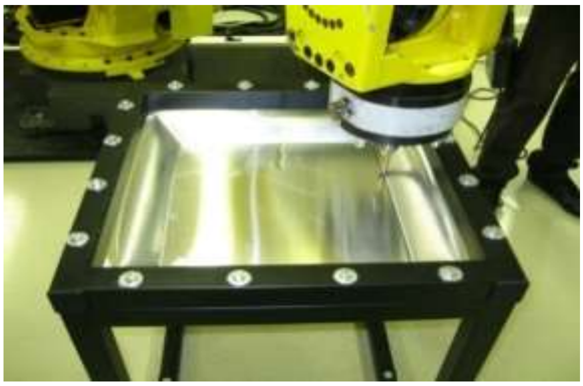

Fig. 3. Incremental Sheet Forming using robot

It is often hard to see whether there is an inadequacy or not (see fig. 4). In this case 3D scanning and then a look at the 3D model can surely help.

Fig. 4. Car body part

It is clear that human visual examination of 3D models of sheet metal parts of EOL vehicles is only a very small segment in the LCM of the given parts, however it may still be a very helpful and important step in the decision making, thus we have to deal with this problem as well.

There is another important area where the ISF technology could be successfully used, namely in medical applications. These applications need a lot of intuition in problem definition, understanding and representation from both the medical and information technology experts. In the first joint efforts they have to learn a "common language".

A medical application

In this study we shall speak only about spinal orthoses (see fig. 5), as physically such a piece of plastic or metal- sheet looks similar to a car body part sheet-metal, thus we hope that similar technologies can be used for design, measurements and manufacturing.

Fig. 5. Spinal othosis

Fig. 6 shows an experimental set-up consisting of a robot and a 2.5D milling machine to make ISF of polymer sheets. ISF of polymer sheets with heating the sheet from one side (small robot) and forming it with an appropriate tool from the other side (milling machine) is an experimental set-up to gain appropriate knowledge about the technology and its parameters and the used materials.

Fig. 6. Set-up with small robot and milling machine

The processes in this setup can be started and monitored even in a 3D virtual world. Optical and other measurements for sheet thinning and thermal behavior are in process.

The goal of this research is to be involved in the medical applications of ISF, namely Orthosis design, manufacturing and repair according to the customer's and doctor's requests. It can be seen in fig. 6. that the recent experiments allow a maximum size of 15 cm ×15 cm for the sheet. For a real, spinal orthosis we shall need a workspace of at least 100 × 50 × ×30 cm, which can be managed easily, just the fixing and the machines should be substituted by bigger, more powerful ones. Wikipedia explains orthisis using professional sources - it is no shame to cite - and simplifies the text sometimes, what is an advantage for the recent study. An orthosis is "an externally applied device used to modify the structural and functional characteristics of the neuromuscular and skeletal system" [13]. An orthosis may be used to assist in several ways, all worth to studying, but here we mention only those, which may relate to spinal orthosis, i.e.:

- To restrict movement in a given direction or to assist movement generally;

- To reduce weight bearing forces for a particular purpose;
- To otherwise correct the shape and/or function of the body, to provide easier movement capability or reduce pain.

Orthotics combines knowledge of anatomy and physiology, pathophysiology, biomechanics and engineering. Patients benefiting from an orthosis may have a condition such as spinal bifida or cerebral palsy, or have experienced a spinal cord injury or stroke. Equally, orthoses are sometimes used prophylactically or to optimise performance in sport.

Orthoses were traditionally made by following a tracing of the extremity with measurements to assist in creating a well fitted device. Later the advent of plastics as a material of choice for construction necessitated the idea of creating a plaster of Paris mold of the body part in question. This method is still extensively used in the industry. Currently CAD/CAM, CNC machines and even 3D printing are involved in orthotic manufacture.

Orthoses are made from various types of materials including thermoplastics, carbon fibre, metals, elastic, fabric or a combination of similar materials. There are several applications of orthoses, as for example for limb, foot, ankle, knee, etc. but now we deal only with Spinal orthoses. We plan to use the ISF technology for creation and repair of plastics orthoses.

Scoliosis, a condition describing an abnormal curvature of the spine, may in certain cases be treated with spinal orthoses. As this condition develops most commonly in adolescent females who are undergoing their pubertal growth spurt, compliance with wearing is these orthoses is hampered by the concern these individuals have about changes in appearance and restriction caused by wearing orthoses.

There are a number of spinal orthotic designs common to assist individuals with pathologies of the neck and back. A thoracolumbar spinal orthosis (TLSO) is a plastic body jacket to immobilize the thoracolumbar spine, although that term describes any type of orthosis that encumbers the trunk, ranging from soft corsets to metal braces to strap and pad designs that affect pathologies ranging from back pain to scoliosis to fracture. TLSOs may also be used in the treatment of stable spinal fractures.

Without going into any medical or information technology details we can see that there are different kind problem statements, solution possibilities and necessary decisions on both professional sides. For example we should decide whether to make a new orthosis from a piece of new sheet material, or use an old one, and apply re-make (re-shape) technology. If the decision is re-shape an existing orthosis for patient B one has to decide: reshape and old piece of the patient B, or re-shape an old orhosis of any patient A for patient B.In every decision there are several points to see and to evaluate, thus all decisions are rather complex: medical and computer science knowledge, measurement and programming capabilities, material science knowledge and lots of other things are needed. Human participation and equilibrium of human and machine intelligence are equally necessary. At the same time accumulated experiences and data and knowledge sources – residing in several computers of the world – have to be present and assist the designer, operator, etc. - through sophisticated networks of different computers. The reader may understand already that he authors intention is to show the way to Cognitive Info-communication due to the several human and machine- players of the game, with a huge number of relationships – but still all have to be managed and used.

3D MODELLING AND SIMULATION

We have developed the 3D models of the components (robots, machines, and their environment) of the examined processes, and after that we have tested them in the course of execution. The basis of our tests is a 3D virtual environment (VirCA 14].), with which we made our models alive in the cyber space.

CREATION OF 3D MODELS

We have created the 3D models of our system and its environment (see fig.7) using 3D designer programs, mainly Google SketchUp 8 [15]. Some of the original 3D visual components have been created in other graphic modeler programs (e.g. SolidWorks, Solid Edge) using different file formats (e.g. STEP, DAE) that have been imported to Google SketchUp. In some cases Autodesk 3ds Max has been used for transforming original files to 3DS format that has been imported to Google SketchUp, too.

Fig. 7. Model of Fanuc robot and its environment

First we tried to create the 3D models of the above mentioned car body parts by using a Kinect sensor [17] and applying the free, non-commercial software, ReconstructMe [18]. The first trials were promising, but the models were not detailed enough, and due to the non-commercial version disturbing additional spheres were added intentionally by the software (see Fig.8) as disturbances.

Therefore in order to avoid the spheres we are going to use the commercial version of ReconstructMe, and another input device, called carmine [19] in order to improve the details of the scanned models.

VIRTUAL COLLABORATION ARENA

The Cognitive Informatics Laboratory of SZTAKI developed a Virtual Collaboration Arena (VirCA) [14 & 20], that has been used for the modeling and control of our applications [21].

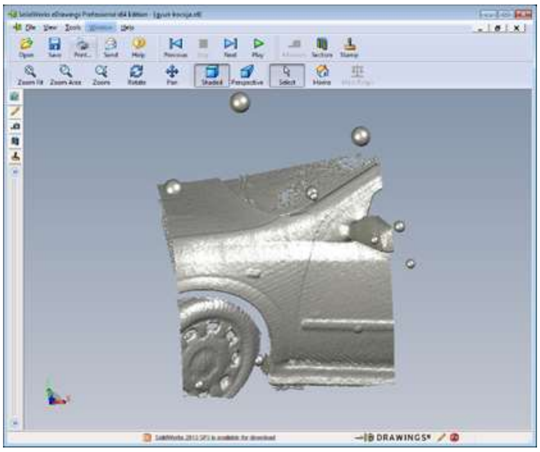

Fig. 8. Scanned car body part

VirCA is a component based, distributed, interactive virtual reality manager system for connecting, as well as displaying and manipulating virtual and real objects, realizing collaboration that way. VirCA handles real, physical as well as virtual spaces in order to realize distributed, interactive collaboration.The innovation of the VirCA system on the other hand is the connection of virtual and real physical devices. The user can see and manipulate the different, usually distant devices together. With the help of the virtual objects, the cooperation of such real devices far from each other can be tested without the development of a simulator.

Applications of the 3D models

Since the graphic engine of VirCA is Ogre [16], therefore the visual components of all models have been supplied in Ogre (mesh and material files) format. The mesh and material files have been exported from Google SketchUp, using “SketchUp to Ogre Exporter” plug-in.Using ReconstructMe we can digitalize the damaged car body part and save it in STL format, from which we can create the 3D models for better (stereoscopic 3D) visualization, as well as for the CAD application (SolidWorks) in which we can manually reshape the model of the damaged parts. Using an add-in software of SolidWorks, called SolidCAM we can generate the tool path for the ISF application from the reshaped 3D model of the damaged part. In this way using ISF we can either reshape the real damaged part or remake the part from new sheet metal. As most real sheet-metal parts of cars are larger than 50 × 50cm we work on a larger fixing equipment.

Fig . 9 presents a general view of the different graphic formats of the 3D models and their connection to the VirCA system and to the ISF application.

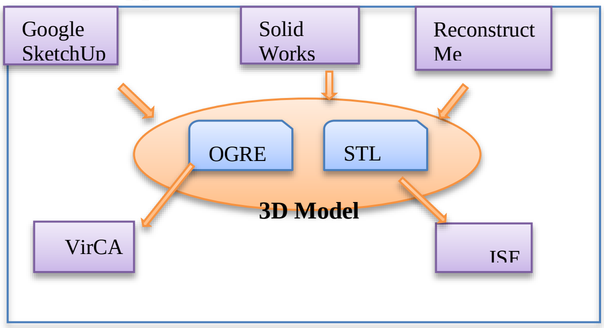

Fig. 9. Fanuc robot in VirCA

Operation of the 3d models

The VirCA environment allows us to be in a virtual environment and interact with it knowing that all the actions will be also done in the real environment. This way several parameters, as well as the model of the industrial process can be examined both in the virtual and in the real system .

A special web based tool [22] supports the connection of the different programs with the proper interfaces, and activates the whole system via the Internet. It controls the states and connections of all the affected components, even though they might be

VALUE CALCULATIONS IN PLCM

When we deal with dismantling of EOL vehicles, and take a set of rather important questions under examination we should not forget about costs. It may easily happen that a part is pushed through our suggested long and sometimes complicated decision process and then a re-make or re-use process is done using human and machine resources, and finally the value chain results in financial losses. And this is a simplified value chain as costs are calculated from human and machine resources, energy, paint, and some additional costs. available from the different parts of the world.

Finally the calculation is something like this: "I do the repair if I can sell the repaired part for more than the costs of the given part + repair works + energy, materials, etc." However this calculation does not correspond to the requests of sustainability, of energy and water saving i.e. of our future. In the future we have to take into consideration the "footprint" and "side effects", too.

These mean that the environment may be damaged by some works, or some extra water or energy are needed, which are not taken into account, however they are contributing to a general water and energy shortage In this last part of our study a calculation method and some further ideas are presented to estimate the product values at each level of the PLCM for any kind of firms, SMEs in production, service, etc.

These calculations might help to evaluate re-cycling, re-use and/or dismissal of products, used parts and group of used parts. This will be a rather sophisticated numerical evaluation method in the future to assist decisions for programs and for the human. However these are only ideas today, as no precise calculations are supported, just some trends and directions can be concluded based on them.

Numerical comparisons are foreseen based on the TYPUS metrics and *KILT* model (for details see [23–25]) are given below to make go/no go decisions easy, and often give answers to the question: worthwhile?

The typus metrics

TYPUS metrics means Tangibles Yield per Unit of Service. It is measured in money – on ecological basis. It reflects the total energy and material consumption of (all) extended products of a given unit, e. g. of an enterprise of any kind.

The metrics assumes several important aspects, and it is open for further points of view.:

- to define a scale for measuring the lifecycle function supplied by the artefact,
- to record the material and energy provisions during the manufacturing phase,
- to record the material and energy provisions during the operation service,
- to evaluate the material and energy recovery at dismissal, reuse and recycling.

To demonstrate the difference between tangibles (for example a piece of metal) and intangibles (defined by the shape and function, for example a spoon made from the metal), there are some simple provisions.

Provision of tangibles:

- Extended warranties (supply maintenance) and
- Temporary allocation of artefacts (leased commodities)

Provision of intangibles:

- Temporary use of artefacts (shared commodities) and
- Dematerialized assignments (function delivery)

TYPUS, tangibles yield per unit service: the measurement plot covers the materials supply chain, from procurement, to recovery, so that every enjoyed product-service has associated eco-figures, assembling the resources consumption and the induced falls-off requiring remediation. The results are expressed in money, resorting to the arbitrariness of establishing stock-replacing prospects. The point is left open, but it needs to be detailed, to provide quantitative (legal metrology driven) assessment of the "deposit-refund" balance.

The metrics is an effective standard aiming at natural capital intensive exploitation. The supply chain lifecycle visibility needs monitoring and recording of the joint economic/ecologic issues, giving quantitative assessment of all input/output materials and energy flows.

When a metrics, such as TYPUS, is adopted, conservative behaviors are quickly fostered. The ecologic bent of the taxing systems becomes enabling spur, to turn the "knowledge" paradigms towards environmental friendly goals. The TYPUS, tangibles yield per unit service, metrics can, of course, take other forms. The objective is to look after capital conservative arrangements, notably, as for the natural assets. In different words, the objective is saving the wealth (the capital), and to tax the consumption (the imbalance of the natural resources).

The KILT model

KILT is an arbitrarily and at the same time properly chosen implementation of **TYPUS**, we could imagine other realizations as well. However the recently given definition seems to be the best to be used for the requested goals.

The refunding needs synthetic models describing the manufacture processes. With earlier models the delivered quantities (all outputs), ***Q,*** which are assumed to depend on the contributed **financial (*I*) and human (*L*) capitals** only.

$$Q = f(I, L)$$

Linear input/output models are assumed for instant marginal description of the quantities, or for related increments around an optimal setting. Enhanced models are in use, to include market entry thresholds (Imin and Lmin), or saturations (Imax and Lmax).

Similarly, instead of bi-linear dependence, close to steady state, the lack of symmetry could have resort to modulating exponentials.

The **know-how (K)** innovation and the **tangibles (T)** bookkeeping have non negligible effects. (Remember: ***I and L*** are financial and human **capitals**) The modified – and stronger, more closed to real life – relationships become:

$$Q = f(K, I, L, T)$$

$$Qo = oKILT; \quad \text{or, incrementally}$$

$$dQ = oKILT - (kK + iI + lL + tT)$$

The value of **dQ** (delta Q) **corresponds** to the **value of change** between any two life-cycle **phases p1 and p2.**

The calculation of dQ means a kind of multiplication of the four basic values K, I, L and T. If any of them has a value zero or close to zero, the yield will be close to zero as well. There is a lot to think about the applied values and dimensions and on the necessary balance.

CONCLUSIONS

All the fields of the presented and related research are (or can be) directly connected to Cognitive Info-Communication. See [26] in addition.

Some of these relationships were explained earlier in this paper, others are only mentioned without going into explanations. A short list is given, as examples:

- 3D modelling, - scanning car body parts,
- computer networks with distributed programs,
- knowledge assisting several programs in solving problems of all kind,
- using intelligent decision support, etc.

Vehicle dismantling (including re-use with or without repair and re-cycling) is very important because of energy, water and material shortage on the earth. Due to the complexity of the tasks and decisions as well as to the high level of computer/human cooperation new methods should be used, as e.g. the above mentioned Cognitive Info-Communications. To calculate values and compare them at any level of the Product Life-Cycle Management (PLCM) at any detail the **TYPUS** metrics and the ***KILT*** model were discussed and suggested as possible, but not yet enough elaborated tools and means.

ACKNOWLEDGEMENT

This research and the establishment of the robot laboratory were supported by MTA SZTAKI. VirCA was provided by our Cognitive Informatics Laboratory.

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METADATA

Title: Some practical applications of cognitive info- communication

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Language: English

Source: SIIT, no. 1, pp. 5-14, 2019. ISSN 2658-5014 (Print).

Abstract: Some tools and methods of Cognitive Infocommunication can be applied in waste material management, where the goal is to minimize real waste, applying re-use and re-make instead of re-cycle. Examples are given to show some problems and solutions, such as car sheet-metal parts, and orthosis as a medical application. 3D modeling and visualization assist the processes, as for example to support human decision making, and to create the tool paths to control Incremental Sheet Forming robots used to re-shape damaged or new parts.

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