Brain to Machine-Computer-Mind Interfaces   (Reflective remarks)

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"It is humbling and more than a little frightening to realize that we rely on what may be the most complex structure in the universe   with   little   knowledge of how it works." (Louis Cozolino)

Abstract

This paper is an attempt, using a concise HSL notation,   to describe some aspects of brain interfaces. It is focused on two brain interfaces having different functionality. One - BCI (Brain to Computer-Machine Interface) is related to neurophysiologic signals,   while a second - BM$_d$I *(Brain to Mind) is   focused on mental (cognitive & psychological) information and acts as a mapper of brain signal-based "engines" into "mental views". Mental processes act in many cortical regions thru biological neural networks and some of them are   briefly characterized.*

Keywords

brain, mind, brain2mind interface, biological neural networks, artificial neural networks, BCI, NCI, BMI, BMdI, BDI, HSL-OSL, specification language, mapping brain to mind.

Introductory remarks

A brain is the most important, interesting and mystic organ of human-being. Resarchers have been trying to explore this "territory" by means of brain-machine/computer-interfaces (BCI)   and   by an investigation of biological neural networks using artificial mathematical models.

A BCI is currently defined as "a system that measures central nervous system (CNS) activity and converts it into artificial output that replaces, restores, enhances, supplements, or improves natural CNS output "[3]. This is an independent of peripheral nerves and muscles output pathways channel for controlling a device through neural signals to perform dedicated tasks. [14]

BCI can be defined, in short, as a neural control interface (NCI) based on medical devices.

1. Human Specification Language (HSL)[1]

<!...> comment < > container		**ppppXxxx item Xxxx with prefix 'pppp '**	
<noun> denotes a class (the plural)		**UUUU.xxxx xxxx belongs to UUUU**	
<def > </def> start end of definition		**& / /+ conjunctions 'and' 'or' optional plus**	
● located in » « outside interface		**Σ neural network, Ξ layer(I,M,O) <input,middle,out>**	
⇒ mapping or multitracks		**↔ bidirectional passive unary relation 1:1**	
{.[.(..).].} nested list of items		**→ forward unary passive relation**	
¦ optional │± replaceable ┤ blocked, ‖ isolated		**<=> complex or many to many active relations**	
xxxx(..) name of list		**<=, => backward, forward active relations**	
: equivalent :: belongs to		**@/dark unknown, to be obtained, to discovere**	
=: definition = contents # number of		**,.. more, ,… much more**	
¥ output Φ function		**? to be verified ?! …………....verified**	

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[1]   HSL is a subset of OSL - Object Specification Language (see appendix)

process(actions(events)) .e.g.pr(ac1,ac2,ac3)	s(ev1,ev2,ev3, ..)<!sequential flow of events>
ac(ev1,ev2,ev3) <!action-sequence of events>	p(ev1,ev2,ev3, ..)<!parallel flow of events>
<!mixed flow>	pr(s(ac1,s(ev1,ev2,ev3),ac2(p(ev4,ev5,ev6),(ev7,ev8))

Human-being is "an open system which maintains a constant state while the matter and energy which enter it keep changing"[7 p.11] . A brain is the commander of such behavior. Our mind is based on our brain, but the quality of both   is changeable depending on genetic code, health's state, breeding, education etc.

subject HUMAN
    class1[animals.mammalia.primates.homidae.homo-sapiens]
    class2[nation.ethnic-group.person]
    ENV[WORLD,CONTINENT,COUNTRY,REGION,SITE]<!environment>
    ENV.cultural[tradition,history,education,religion,ideology,art,mass-media]
    ENV.geogr[homeAddress,company/school]

 object PERSON
    object.nfo[id,sex,birth-data]
    invariables[id,sex,birth-data]
    homeaddress[country,site,street,house,flat]
    sex[male/female/x]
    body{[nervous-system=:GNS(CNS,PNS,ANS(ENS))]
            <!globalnervous-system(central,peripheral, autonomous(enteric,..))>
            CNS(brain,..),ENS(neurons(sensory,motor,inter)),heart,lung,liver,kidney,joints,..) }
    mind[wisdom(thinking,reasoning,learning,recognizing,communication),knowledge,...)]
    family[gentree,parent,child,son,daughter,grandSon,grandDaughter,granMa,granPa]
    complexEmotion[love,hate,satisfaction,frustration,agression,enjoyment/pleasure,anger,..]
    elementaryEmotion[hunger,thirst,chills,pain,..]
    complexPsych[fear-of-insupport,regression,inferiority,persecution]
    habit,hobby,profession,
    health[measures,physical-examinations,illness-history],
    role[advisor,consultant,manager,patron,partner,customer,
        supervisor,participator,owner,supplier,
        user,analyst,designer,programer,operator] <!plus 'role' in kernel>   ,
     appearence depends on,assisted by,belongs to,matched/matches,
     relations<!plus relations in kernel>
     relates to,used by,uses,not used,misused,abused,
     state[active,inactive,dormant,suspended,aborted,idle,lost,dead,
         homeless,retired,married/divorced/single,ignored]
     place[point, area,everywhere,nowhere]
     life-space[psychological,social,educational,professional,financial]
     behaviour<!flow of processes of the object >
     behaviour.rational[selfrealization,need,satisfaction]
     behaviour[marriage,friendship,career,illness,aging]
     genotype,fenotype
     olh:=[birth,aging-curve,social-events,health_illness-events,
        educ-events,job-events,critical_events,death]<!object-life-history>
     cluster{<! cluster is a global feature estimated on the base of several characteristics>
        [self,profile/type,attitude,leadership,ability,extraversion,anxiety,independence,healthState,
         lifeStyle,creativePotential,happiness,BipolarPersonality]
         self[self-identity,self-assesment,self-sentiment,self-esteem,self-regard,self-reliance,self-control,

self-image,self-extension,self-structure]
leadership[assertive,creative,facilitative,independent,stable,permissive,leadership(Style,Potential]
ability[toughMinded/openMinded,creative,fast/slow,toleratesDisorder/perfectionistic,
grounded/abstracted,improving own learning,problem solving, IQ, ...]
need[biological(food,medical,emergency,rescue, coping), cultural,
psychological(love,esteem,selfrealization),financial-resources,security]}
BipolarPersonality[Warmth(reserved/warm),Reasoning(concrete/abstract),
EmotionalStability(emotional/stable),Concillation(concillatory/aggressive),
Dominance(deferential/dominant),Liveliness(serious/lively),
Openness(extraversive/introversive),Tension(relaxed/tense),
Rule-Consciousness(expedient/rule-Conscious),SocialBoldness(shy/socially-bold),
Sensitivity(utilitarian/sensitive),Vigilance(trusting/vigilant),
Abstractedness(grounded/abstracted),Privateness(forthright/private),
Apprehension(self-assured/apprehensive),
Self-Reliance(group-oriented/self-reliant),
OpennessToChange(traditional/open-to-change),
Perfectionism(tolerates disorder/perfectionistic)].

2.Brain

A brain is the main part of central nervous system (CNS) and is defined as "a self-organizing, self-modifying organ with learning, memory, and categorization capabilities that recruits our sensory and motor systems in order to identify patterns in, model, and modify the external world".[1] (p.114)

human-nervous-system[central-nervous-system(brain,spinal-column),peripheral-nervous-system]

brain[forebrain,midbrain,hindbrain]
forebrain[thalamus,hypothalamus),basal-ganglia(caudate-nucleus,putamen,globus-pallidum),
cerebral-cortex]
midbrain[tectum,colliculus(superior,inferior),tegmentum,substantia-nigra]
hindbrain(brainstem:reptilian-brain,cerebellum,medulla,pons)
brain-area[cortical-region,subcortical-region,nucleus(clump/layer)]
subcortical-region[thalamus,globus-patlidus,putamen,substantia-nigra,corpus-striatum,..]
cerebral-cortex:neocortex[lobe(frontal,parietal,occipital,temporal)]
cortical-region[primary-visual,entorhinal,inferior-temporal,orbitofrontal,
lateral-prefrontal,inferior-parietal,..]
functional-cortex-area(visual,sensory,tactile,auditory, ..)
somatosensory-system[subsystem1(touch,pressure,pain,tickle,itch,vibration,temperature,
proprioception,kinesthesis),subsystem2(sight,hearing,taste,smell)]
multifunctional-cortex-area
[limbic-system(amygdala,hippocampus,hypothalamus,septum,cingulate-gyrus)]
*A limbic system is involved in the regulation of emotion, but affective processes spread out also
on ventromedial regions in the prefrontal cortex.*[38]

micro-part[neuron,synapse,receptor,unpaired-electron,neurotransmitter,glia-cell,..]

neuron{[soma-nucleous(mithochondria,membrane,cytoplasm,vesicle,perycarion),
myelin-sheath,schwann-cell,axon,dendrite],
#active-synapse(connections),synapse(excitatory,inhibitory)
<!*synapse is a place where signals are modified by weights*>,

activity-level(input,trigger,conduction,fire-output) <!*actual function of neuron*>
        <!*receives many signals, outputs signal to one or many neurons*>,
    input(electrosignal,chemical-pharmacological,natural-signal(light,sound,pressure),..)]
    form(multipolar,bipolar,unipolar),creation-type(primary,new-born,»mirror[2])]}

  brain-basic-function[sensory(vision,hearing,smell,touch,...),
                        motor(eye-movement,voluntary-movement, ..)]
  brain-mental-function{
    mental-basic-function(association,speech,emotion,language-comprehension,coordination,...),
    mental-complex-function[consciousness(self,..),cognitive-activity,wisdom,intuition,.].
    cognitive-activity(attention-coordinating,decision-making,movement-selection)
    mental-hidden-function(intuition,premonition,..)}
  mapping[engine ⇒ view, view ⇒ engine]
     view{natural[electrophysiological,biochemical,psychophysical,..]
     conceptual(semantic,psychological,mathematical,ontological,,..]}
     engine[thinking,emotions,info-retrieval,memorizing,communication,...]
  communication[comm-layer[stream[message(carrier,protocol,pattern),signal]]]
  signal(electrical,magnetic,electromagnetic(photon,..),chemical,natural),
  communication-layer(single,multichannel)
  neurotransmitter[#60(acetylcholine,glutamate,y-aminobutyric-acid,glycine,oxytocin,
     vasopressin,endorphins,serotonin,dopamine,..)]
  diseases[dementia-senilis,alzheimer,parkinson,tourette-syndrome,huntington,stroke,amnesia,
     ataxia,aneurysm,concussion,delirium,atrophy,obsessive–compulsive-disorder,split-brain,
     sclerosis(multiplex,lateralis),hydrocephalus,amyloid-angiopathy,spinal-cord-injury,...]

3.Neural networks

An investigation of neural (neuronal) networks is necessary to fully understand   the brain behaviour. Mapping some supposedly separated brain neural networks into artificial ones could be done successfully, while "screening" the whole brain (or dispersed area like limbic system) to the assembly of interconnected networks is a very complex task due to complexity and embedded plasticity of brain when passing many changes of wiring (a synaptic coupling) between neurons in response to inputs and new experience. Examples of interdependent neural networks are networks of spoken language and motor control.

A complexity of brain biological networks is very high (almost hundred billions of neurons & trillions of connections) and activity of them is classified as a biological computation. Connections are made by activation of neural circuits (neurons[3] or fields[4]) having required action potential (all or nothing way) and triggered by many events (emotion, motor imagery signals, narrative speech, stress, psychotherapy, medications internally acting mostly thru biomolecules[5]). A response from the target cell is such as the generation of an action potential, the contraction of a muscle, the stimulation of enzyme activity and   chemical, electrical and blood flow changes. Neurons are able to fire either in a burst (after a period of hyper-polarization) or a tonic manner.

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2   "copy" from outside (during communication with another person)
3   MUA and SU signal aquisition
4   LFP signal aquisition
5   enzymes, proteins

Active neuron is alive neuron - making connection or being connected is for the neuron a question "to be or not to be".

Examples of brain neural networks are: nerve tracts connecting   left and right cerebral hemispheres , the left and right temporal lobes, visual area (located in the occipital lobe)   with retina and thalamus.

Artificial neural networks **ANN**   could   roughly simulate some biological ones   using mathematical formulas. They work in multilayer mode and consist of input layer, hidden middle layers and output layer. An output is formed from a set of many inputs mostly by learning technology and nonlinear activation function. There might be a problem for training neural human network   because the need to supply thousands exemplary data. [1 p.428],

ANN-artificial neural networks
    {[convolutional[6],learning-vector-quantization,fuzzy,gaussian-kernel&radial-basis-function,
      bayesian-logistic-regression,gamma-dynamic,finite impulse response,hopfield,kohonen, ...]
      neural-network.parameters[layers(input,intermediate,output)(hidden/visible),
      connection-between-layers(backpropagation,...),variables,expected-values,weights,weight-rules,
      learning{[method(supervised,unsupervised,reinforced] <!*determining the weights*>,
      layer[(feedforward,recurrent),single-layer(perceptron-like,adeline),multi-layer]
    density,#layer(#node,#cell[7]),changeability-level]}

BN-biological:natural-network[
    type(neural,biochemical,species-interactions,biochemical,species-interactions,..)
      biochemical(metabolic,protein,gene,..),
      species-interactions(food-web(prey,predator)),host-parasite networks),
      space(intracell,regional,multiregional,dispersed,....)
      regulatory-biomolecules(enzymes,proteins,...)…]

Many things are to be discovered in brain neural networks **BNN**   because the complexity of interrelations. Human single cell could have up to 10^{170} possible molecular interactions that might create considerable computing challenges[8]. Neural networks and gene regulatory networks (GRN) are internally dependent as a neuron contains the whole genome.

    BNN{(corpus-callosum,visual,memory,basic-functions,retina,language,social,..)[9]
      [nerve-tracts(commissural●corpus-callosum,association●hemisphere),
            projection(cortex <=> subcortical structures)]
    Σcorpus callosum[Ξleft cerebral hemisphere <=> Ξright cerebral hemisphere}
      <!*essential for integration of cognitive and emotional functioning*>
      <!*if severed => (split-brain): conflictual behavior(i.e.hands discord),epilepsy,anxiety,*
          affective-disorders,psychosis,alexithymia,disruptions of the self.. >[10]
    Σvisual[Ξretina(Ξphotoreceptors,Ξ interneurons,Ξganglion-cells)
      => Ξthalamus(messages) => Ξvisual area ●occipital lobe]
      <! *puts together the color, motion, orientation, depth information to "see" the image*>
    Σmemory(Ξhippocampus<=>Ξparahippocampal)
    Σbasic-functions(Ξmedula<=>Ξspinal-cord) <!*swallowing,heart rate,breathing*>

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6   fNIRS time series data as input to the CNN

7   #glia-cell in brain network

8   Information from: Ben Brown head of Berkeley Lab's Molecular Ecosystems Biology Department co-author of "Iterative Random Forests to Discover Predictive and Stable High-Order Interactions

9   some of widely known brain neural networks.

Σsocial(Ξmedial-prefrontal-cortex<=>Ξposterior-superior-emporal sulcus)
Σlanguage{left-hemisphere[lobe(temporal,occipital,parietal) **Φ**convergence(auditory,visual,sensory)]
  ¥≡>(wernicke's-area,broke's-area,..) [right-hemisphere **Φ** feature-of-speech(emotional,prosodic)]}
Σmotor/muscles[10]{primary-motor-cortex[tract(dorsolateral:pyramidal,ventromedial)] ≡> spinal-cord, }.
Σspatial-attention(posterior parietal cortex,frontal eye fields)[11]
Σface-recognition(middle-cortex, temporal,temporopolar cortex)
Σself(posterior-cingulate-cortex,medial-prefrontal-cortex,inferior-posterior-lobe)[12]
ΣglobalNS(CNS,PNS,AMS(ENS)) <!global network system>.

4.Brain interface

We suggest to distinquish two kinds of neural interface: very known BCI (interfacing to devices) and BM$_d$I (interfacing to mind). The first deals with physiologic signals and the second one with information expressing mental and psychological phenomena.
BCI could help in diagnose and treatment of many impairments using effector devices (computers, game, wheelchair, speech-synthesizer, assistive-appliance, neural prosthetics,..). BM$_d$I seems to be in predefinition state yet, but would play the important role in treatment of mental disabilities. These two interfaces are complementary and show two sides of the same phenomenon.

BCI *<1Brain Computer Interface>*
  category[(unary,multi/hybrid),(med-standard-device,biologically-interfaced-device(PSbased,..))]
  hybrid(multi-brain,multi-device(multi-sensory-stimuli,multi-modal-signals),...)[13]
  action-type(active,reactive,passive,..) standards[IEEE(...),ISO(....),..]

bci-operating-schema[SourceObject,stream(message), ¦amplifier,transducer,control-interface,
  user-device-dedicated-applications,ReceivingObject(action,reaction),summary-report]

SourceObject{[unary(personId)/multi(groupId)[cortical-region[layer]/
    cytoarchitectural-map(#52-electrode-placement-code),signal-capture-device}

transducer[(signal-acquisition,preprocessing(artifact-noise-removal,filtering,
    feature-extraction(AR,ARR, neuron-firing-rate,potential-amplitude,...),
    classification,..),output(classifier label[14],..)]
    <!noise-sources(neural,non-neural(eye-movement,muscular-movement,electric-line)>
    <! due to the eye blink movement, a spike is formed in the signals>

control-interface(encoding(logical_symbols LS=>semantic_symbols SS),*feedback)*

filtering[of(amplitude,latencies,frequency(theta,beta,alpha1,alpha2,gamma),uncorrelated signals..),
    method(band-pass,recurrent-quantum-neural-network,statistical,Fourier-Transforms,.),
    spatial filtering method[15](CAR, PCA,ICACSP,surface-Laplacian,bipolar reference)],
        <!for spatially distributed signals>,
    statistical(PCA<!Principal Component Analysis>,ICA<!Independent Component Analysis> ,..)]

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10 [38]
11 [39]
12 [40]
13 Interesting example of hybrid interface: optogenetic stimulation combined with ECoG[37]
14 represents the identification of brain pattern
15 specification based on [3]

classification[training of classifier(EM,..),(clustering(class,multiclass,nonclassified)),
.   method(regression,derivative-approximation,Bayesian,Fisher,loss-function,LDA,SVM,HMM,
          neural-network(semipartial-recurrent,convolutional),((DT(ZeroR,1R,divide&conquer,),
          k-NN,NB,RBF,SVM,LogReg,Ada-Boost,Bagging,Stacking,RF,Boosting)[16]..)],

ReceivingObject[effector-device /& computer,human-object(feedback2(brain,limb,..))]

action[stimulation(muscles/&nerves), mental-typewriter,cursor-move,speller,game,painting,.
          device-commands(neuroprosthetesis(artificial limbs),wheelchair-control)),..]
stream{(signal-source,signal-capture-device)<≡> receiver/device),
          [message(signal(impulse)),flow-type]}

stream-parameters[standard(type,id, encryptionCode,securityCode,timeStamp)
          extended(timeInterval,duration,populationShape,dynamics,
                    dispersion,measureUnit,accuracy,disturbance)],
stream-trigger/actuator(event/erp,time,demand,)…}
  <!stream is one/multi-channel collection of messages directed to one receiving device>
  <!message is one-channel sequence of signals issued at a given time >
  message[cp,data]]<!cp:*comm:communication protocol*>

comm-protocol(tcp/ip,udp,i2c,spi,can,hart,ethernet,wifi,rf,bluetooth,nfc,satellite,6lowpan,
                    mqtt,zigbee,coap,z-wave,uart,modbus,device-embedded,BCI-p,HL-7…)
session[session-mgr,,.)(run1(stream1),run2(stream2),..)]
operating-mode(training,testing,working,..)
flow{type[cerebral-fluid,cerebral-impulse,blood,...]
user-report[<contents>,standard(HL-7.2/7.3,..),data-set(FHIR,NPX,XML..),..]
device-summary-report[brain-degradation(ratio of neuron(lost,active) in subcortical-regions),
          dynamics,...),impairment-symptoms..,personal-bci-sessions-journal]

DEVICES

  Standard-device-function(recording,diagnosis,monitoring,treatment,alleviation-assistance, .).
  device-category(signal-aquisition,effector,…)
  signal-aquisition(EEG,MEG,PET,fMRI,DTI,NIRS,EOG,EMG,sEMG,ECG,EcoG,SPECT,TMS,..)
  signal-type[(magnetic,electro-magnetic,electrical,chemical,enzymes,proteins,fluid/blood-flow),
          electrical(SCP,P300,N2pc,N400,SSVEP,SSEP,SMR,c-VEP,..)
          potential(ERP(P300,P100,P50,..),SCP,TTD),EEG(SSVEP,SCP,..)]
  medDevice-feature{[signal-aquisition-method,communication(embedded,external),
          software(embedded,external)] [triggered-by(event,time,demand, …),
          link-mode(<=>,<= , =>,←,→)]}

signal-aquisition-method[sensor(electrode(type),CT(X-ray),MRI(magnetic-resonans),
          NIRS(resonance of oxygenated&deoxygenated haemoglobin)-used in cortical tissue,
          fMRI(mri+blood-flow,oxygen level) used to measure neural activity throughout the brain,
          DTI(mri+water molecules),EEG(electrical waves)...),
          placement(cortical-region/point-of-contact/placement-code/..)

[invasive(greymatter)/semi-invasive(above-cortex,beneath-duramater)/non-invasive(skull),
    invasive(*inside-of-skull,intracortical*),semi-invasive(ECoG,..),
        noninvasive(EEG,MEG,PET,fMRI,NIR,..)]

medDevice-category[stationary,mobile(bluetooth,wifi,internet),stand-alone(touch,cable)],
        medDevice[signal-aquisition,assistive-device(muscle-detection (eye-movement-EOG,
        facial-muscle-EMG,..),neuro-headset,neuroprostheses(robotic-limbs,..),
        orthosis(hand-grasp[17],cursor-control[18],. .).)]
    mobile-medDevice[smartphone,wearables(smartwatch,smartband,headset,…)],
    medComputer(classic-comp,bio-comp,quantum-comp,bio-hybrid-comp,…)
    effects(direct-effects,side-effects..),contraindications,precautions,patient-state(before,after)],
    risk-of-use(risk-classes),conformity(ethical-directives,standards,technical-requirements),
    directives-standards(ISO(14971,13485),IEC62366,Regulation2017/745,HF/UE,..)
    embedded-software(pacemaker,noise-artifact-removal,frequency-filtering, …),
    noise-artifacts(movement-related,eye-blinking,teeth-grinding,the heart-related,...) ,
    [for each mode(training(user.neural-network,classifier),testing,working)
        operating-protocol(initialization/activation,parameters-setup(for feature extraction,
                        signal-translation,classification,..),error-recognition,output-distribution]

5. BM$_d$I - Brain to mind interface

'The mind is what the brain does' (Marvin Minsky - 1985)

Mental processes are obviously the products of a brain but relations between mind and brain
are not trivial. "Mental states emerge from the interaction between multiple physical and functional
levels"[38}. The "mind" is a tool for thinking, deciding, and remembering [2], that could be
looked at as a neuro-information processing devicer [4] focused on the flow of information
extracted from the world of neurophysiology (signals, brain neural networks,..). Scope of
information includes words, emotions/feelings, thoughts, focus, attention, mental fatigue, stress and
many others.
    *Brain to mind interface is a mapping physiologic face of brain to the mental-cognitive one using the
neural presentation (i.e. neural computation), so it is closely linked to the cognitive psychology and cognitive
neuroscience. This mapping is possible if having detailed layout of neural networks and   computational
models of emotions, thinking, stress, disease etc.* So there is a need for specialized software, not only
filtering and classification of signals as in classic BCI.
    There is a hope that integration of classical BCI and BM_dI opens new ways of medical and
psychological treatment based on factual brain information.

    A mind is closely related to consciousness. This relation is of tricky type: "mind is part of
consciousness but consciousness transcends mind" [11]. The question "where are   situated the
mind and consciousness in a brain ?" may be evasily answered that locations are several cortical
and subcortical regions acting in conjunction.

Mind capabilities are clearly expressed by such personal features as:
    - wisdom: right assessment, choice of solution,
    - ability: tough minded/open minded, creative, fast/slow, tolerates disorder/perfectionistic,

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17   in a tetraplegic patient
18   P300s are turned into mouse pointer motion

grounded/abstracted, improving own learning, problem solving, IQ, ...
.   - assertiveness, creativeness, independence, stability, leadership.....

brain ⇒mind-functions *<!brain to mind mapping>*
somatosensory-cortex,..)<=>[process sensory information(smell,taste,sight,sound)]
hippocampus&parahippocampal<=>[memories(form,organize,consolidate,retrieve)]
hypothalamus <=>[emotions(hunger,thirst,chills,pleasure,pain,..),..]
     <!hypothalamus is a connector between the endocrine and nervous systems>
prefrontal-dorsolateral-cortex <=> consciousness
corpus-callosum <=> unity of consciousness
orbitofrontal cortex & limbic system<=> "self"-identity
limbic system <=> emotions

mind-functions ⇒ brain _*<!reverse mapping>*
process sensory information(smell,taste,sight,sound)<=>lobes of the cerebral cortex
memories(form,organize,consolidate, retrieve)<=>hippocampus&parahippocampal
endocrine&nervous systems connection<=>hypothalamus
consciousness<=>[prefrontal dorsolateral cortex,
                         corpus callosum(unity of consciousness),orbitofrontal("self" identity)]
     The consciousness is a very complex function represented by several cognitive information flows: associative, reflexive, perceptual, emotional, verbal, analytic. It constructs complex changeable networks (not road automaps).
      Locations of emotions and a "self" (including consciousness) are spread over the brain. A limbic system ring-like placements concern several areas in the cerebrum (cingulate gyrus, orbito-frontal cortex, parahippocampus) as well as a number of sub-cerebral structures such as portions of the thalamus & hypothalamus, the nucleus accumbens (in the basal ganglia), the septal nuclei and the amygdala.[5]
     A remembering has also extensive environment. The hippocampus receives input from virtually all cortical areas including the hypothalamus, amygdala and ventral medial prefrontal cortex.
      The army is dispersed but "commander" could be found. Each part of the body has its own 'control center' [21] that is responsible for its functions:
        [movements(motor-cortex),voluntary-movement(frontal-lobe),
         involuntary-function(brainstem),pain&sensations(sensory-cortex),
         judgment&foresight&sbmell(frontal-lobe),
         language-comprehension(parietal-lobe),speech(Wernicke's-area,Broca's-area),
         hearing&intellectual&emotional-functions(temporal-lobe),
         visual-functions(occipital-lobe(primary-visual-area))
         swallowing&breathing&heartbeat&wakefulness-center(brainstem)]

mapping(<engine => view> /& <view →engine>)
engine[thinking,emotions,info-retrieval,memorizing,intuition(trust,love,hate),
     communication,total-brain,..….]
view{natural[electrophysiological,biochemical,psychophysical,medical,..]
           conceptual(semantic,psychological,mathematical,ontological,,..]}

emotionEngine => psychologicalView
emotionEngine[frontalLob,hypothalamus,limbic-system,..]
psychologicalView[love,hate,satisfaction,frustration,agression,enjoyment,anger,
     fear of insupport,regression,inferiority,persecution]

totalEngine => medView *<!total engine refers to the whole brain>*
totalEngine(brainArea/neural network-area,disease-brain-pattern)
medView(disease(neurodegenerative,neurological,..),injury,

neurodegenerative(dementia/alzheimers,parkinsons,huntingtons,..),
neurological(autism-spectrum,tumor,migraine,multiplesclerosis,epilepsy,stroke,..)

Brain pattern of disease could be very complex. For example "pain disorders" spreads out on lateral&orbital prefrontal cortex, anterior cinglate, cerebellum, right fusiform gyrus, pons, parahippocampus, right dorsolateral cortex, anterior cingular cortex, midbrain, anterior insula, nucleus accumbens and more...[10].

totalEngine =>/ → ontologicalView

totalEngine(brainStructure,brainContents)
ontologicalView(brainId,brainAging(neurons(#dead,#born[19],#total)),diseasesHistory,
    brainVolume-dynamics(curve,...),brainUsage)

totalEngine =>/ → energeticView

totalEngine(brainStructure,brainContents)
energeticView(brainId,power-consumption vs aging,power-supply-disturbances)

totalEngine => mindView <!total Engine refers to the whole brain>

totalEngine(neural networks,mind-pattern)
mindView[(active/passive),(medical,logical,semantic,psychological,mathematical,ontological)]
mindEngine[thinking,emotions,info-retrieval,memorizing,intuition(trust,love,hate),
    communication,..]

Concluding remarks

BCI is a poweful promising tool for medical treatment and a wide area of scientific research. It enables to use more effectively assistive and neuroprosthetic devices .that is especially useful for persons with no reliable muscular control (improving weak muscle). BCI biofeedback facility has been used to treat such disorders as hyperactivity disorder, sleep problems, teeth grinding, chronic pain, ALS etc. BCI system contributes in the detecting and diagnosing brain tumor, narcolepsy, epilepsy, encephalitis, coma and even breast cancer.

Simulation of the brain neural networks by artificial ones helps to diagnose nerve disorders, Parkinson and Huntington diseases, heart disease and to forecast the action of various healing treatments. [12]. A neurogenetic modeling of ANN is helping to determine the role of genes in such brain diseases as epilepsy, schizophrenia etc. [22]

A brain is a very complicated object and to improve investigation of it the advanced theory and technology (neuroengineering, cognitive computing etc.) may be applied.. An approximative approach, based on rough or fuzzy sets, could probably help for example in the case of vaguely defined neural networks.

Many topics (e.g. consciousness) remain a mystery. It would be great if using simplified componential models led to finding factors of general importance and thus diminished the need for a detailed mapping of the whole brain to one complete neural network. A solution is not a creation a „biggest" network, because simply increasing the number of layers and artificial neurons does not guarantee better results[20]. Capable ANN should not only function as black boxes (output fits to input, that often means „would be good" instead of „must-be good"), but also has to be sensitive to changeable processes, i.e. number of layers, neurons and connections. SONN (Self-Optimizing Neural Networks) solution is one research aimed at this goal.[33]

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19 "there is evidence suggesting that neurogenesis of nerve cells takes place in the dental gyrus of the hippocampus in adults" [38]

20 The SpiNNaker project [26] is a very ambitious attempt to simulate real work of the brain. Neuromorphic computing platform incorporating over a million ARM mobile phone processors and capable of modelling spiking neural networks of the scale of a mouse brain in biological real time.

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APPENDIX

Zygmunt Ryznar

OSL - OBJECT   SPECIFICATION   LANGUAGE
(geometric view)

OSL is a descriptive language for a formal description of any object in terms of structure, relations and behavior (events, actions and processes). Objects may be concrete (physically existent) and abstract (conceptual, virtual). The physical objects are viewed ontologically. So any object has at least its own name, identifier, properties, structure, interface and relations to other objects, own behaviour and "life-history".   OSL does not concentrate on data structure and documents but on descriptive statements - including geometric figures - focused on the layout and behaviour of objects.

A geometric view could be an inspiration for new type of data in the cognitive computing or bigdata mining, as geometric shapes may be discovered by analysis of various massive information. We assumed that geometric interpretation might be be more accurate and more evocative because it shows imaginably (particularly in case of spiral) the nature of objects at least in terms of space and time. Here, it should be mentioned, that fuzzy sets technology uses a geometric view (trapeze and triangle functions).

There are many geometric figures. Some of them are uncommon (swarm, bunch, blackhole, wormhole, freespace) and become a challenge to be taken up in conceptual modeling.

1 Spiral differs from classic iteration in that sense, that every scroll can possess   different "engine" and content. Quite "powerful" are multistrand spirals. Examples of strands in business could be profit, competitiveness, credit ability etc. Such spiral in a business may illustrate for example the bankruptcy of company which falls into spiral that pilots call the "death spiral". A special type of spiral is an irregular hyperbolic spiral intersecting an asymptote infinitely many times.
   Spiral approach is known in software development where the spiral has four phases (planning, risk analysis, engineering, evaluation) and   project repeatedly passes through these phases in every iteration.

2 Swarm relates to the homogeneous relocatable dense population. The path of moving swarm is a good illustration of global expansion of business or moving a business from one country to another.

3 Free space means unstructured or with no rules of structuring.

4 Tunnel is three-dimensional population with the value X (e.g. the sum of credits) along the time Y and densed acording to the third factor Z (e.g. credit ability).

5 Cylinder differs from the tunnel with the feature that it carries the values on the surface while the tunnel keeps them in the interior.

6 Triangle coud represent "shadows" of object on its 3 angles surface (a-axis, b-axis, c-axis), e.g. for employees population angles are age, education, sex. The father of a triadic approach was famous philosopher G.W.F.Hegel (1770-1831) who used triangle to visualize a 'system of science' as a triangle with angles: logic, nature, spirit.[19]

7 Blackhole marks the irreversible disappearance of the object (e.g. the bankruptcy of the company) and shows the „strength of drawing in" (e.g. a speed of the bankruptcy).

8 Darkbox is a place for a dark (or hidden) information.

9 Cloud means an external container equipped with secure gate to enter it.

10 Neural networks are networks of interconnected layers and nodes, which process information as a response to external inputs   using methods unavailable in traditional calculations. Very known applications of neural networks   are character recognition, human face recognition and signature verification. In business   they are used when solution is not based on a predetermined and preweighted criteria but on the past experience (e.g. in banking area - failures in loan granting, forecast time dependent variables such as net income for each month of a year. Neural networks are applied also in finding trends in large quantities of data (currency, stock exchange prediction).

11 <u>Fractals</u>

a) fractal geometry in multifractal stochastic volatility models that work in the context of dynamic turbulance used for example for modeling market fluctuations. [7].Fractal analysis can roughly be thought of as a way to characterize and investigate the properties (e.g. selfsimilarity) of irregular sets.

b) fractal networks useful to express fractal populations like franchising networks.

An OSL extensions for selected areas – based on the kernel- are defined in subsets: OSL-B (business), OSL-H (human-being), and OSL-S (systems). A subset is similar as a shell assigned for a group of users allowing them to use its own commands and keywords.

OSL-S (OSL for System) may document core features of IT system before, during or/and after design and - if implemented - would be a tool of ASF (Automatic System Factory). It shows a way how to create systems with variable structure using a library of tuneable blocks. So in this case OSL could be a "hybrid" solution both for the specification as well as for execution.

OSL-B (OSL for Business) may cover variety of businesses in terms of information flow, procedures, products and financial flow. An example for the banking is shown in [16]

The OSL kernel contains phrases and keywords common for all areas and environment. Subset defines ones specific for a given area.

<**def OSL**><!kernel>

    <def ENVIRONMENT: ENV>
        ENV[regulations, infrastructure:INFR]
        regulations[legalacts,resolutions,decisions]
        INFR[it,org,hr]:[itINFR,orgINFR,hrINFR]
        itINFR[servers,opersystems,applications,databases,users,prlanguages]
        orgINFR<!org. structure of subject>
        hrINFR<!human resources>
    </def>
    <def globalMapping>
        def subLang[BSL,HSL,SSL]<!subsets of OSL>[21]
        objList<!list of objects>[area,subject,problem,decision,<defined objects>]
        defList<!list of definitions>
        specList<!list of specifications>
    </def>

    <u><!object definition></u>
    <def subject <NAME><!main object name>
    <def <name><!ordinary object/item name>
        object.id<!object identifier>
        object.type{eObject<!elementary atomic object >,
        dObject<!dynamic object >,
        iObject<!informational object >,
        vObject<!virtual object >,
        sObject<!smart object)>,
        sObject[noiceReduction,selfTeach,selfRepair,selfKill,selfRestore,selfRestart],
        oObject<!open object>,
            oObject[tuning(input(parameters,data),output(info,messages),
                    structure(addComponent,addRelations))]

incObject<!incarnation of object>,
binObject:BINDER<!collection of integrated objects>,
copyObject<!copy of object>
 probObject:PROBLEM<!task to be performed>,
interObject<object created by intersection of objects>,
capsObject:CAPSULE<!portion of information reserved for a given user>
interObject[(list of objects) when <condition>
involvedObject[(list of objects) when <condition>]}

<!dynamics definition>
event:ev<!-elementary atomic fact >
operation:op
action:ac<!sequence of operations or events>
process:pr<!sequence of actions and events>
pr[trigger,<actions><events>,endEvent]
dynamics[event,operation/transaction,action,process]
dynamics[ev,op/tr,ac,pr]<!short notation>
dynamics.scenario[evSc,opSc,acSc,prSc]<!event scenario,….>
 trans<!transaction in terms of operating system monitor>
ftrans<!financial transaction>
reverseMode[rev,rAc,rOp,rTr]<!back to the previous state>
scenario:sc<!predicted sequence of actions and events>
scenario.rank[best,middle,worst]
object.Info<!information visible at the moment of access>
keywords:kwords<!additional keywords in def>
olh<!object life history>[timeline,events,aging-curve]

<!Object interactions-relations>
Types of relations[dynamic(thru processes, actions, events),
-structural (whole, component),(active(intrusive,accepted),passive)
relations[role,relation,relator]
role[interface,integrator,component,monitor,commander,
driver,trigger/activator,reactor,agent,executor,generator
locator,executor/performer,initiator,terminator,destructor,
participator,owner,stockholder,customer,supplier;partner,employee]
relation[activated by,activates,assisted by,built from ,
appearence depends on ,belongs to/is owned by ,
exists as satellite of <object>,calls <object> (<interface>),
consists of <parts>,contained in/contains,
controlled by/controls,derived from,
existence depends on,exists when/in/for,
included in,linked to ...by/links,
refers to,relates to,related by affinity,
represented by/represents,involved in,
shared by/shares,used by/uses]
relator <!maker of relation>
 relator(marriage,employment,…..)
 relation:[<item1><phrase><item2><!item1 may be assumed as defined before>
 relation{[singular,iterative(standard,recursive)],[sequential,parallel(many-data_sources),mixed]}
  <! if not specified – singular and sequential are assumed>
  <!iterative but not necessarily approximative
  <!iterative normativ – result of each iteration is taken>
  <!iterative approximativ – final result is taken - for example when teaching of neural

network>
            state[active,passive,dark,dormant,suspended,aborted,invasive,intrusive
                 variable,invariable,idle/waiting,lost,expected,deleted,homeless]
            status[generic,real,virtual,undef ined]
            reactor[acceptance,rejection,constructor]
            rank[critical,necessary,most wanted,optional,worst,best]
             rule[decision-table,when-if,formula].

 layout[shape(gProfile1),gProfile2,sparcity,density,variability]

<def gProfile1><!standard-geometric profile>
        [free-space,swarm,bunch,network,neural-network,hierachy,line,triangle,tunnel,
         curve,spiral,spring,circle,elipse,cylinder,sphere,ellipsoid,con,doublecon,prism,
         fractal,fractal networks,squarepiramid,container,blackhole,wormhole,cloud,darkbox]

    <def spiral>
       spiral[single-strand,multi-strand]
       spiral[helix,logarithmic,hyperbolic,polygonal,rational,golden,
            spherical,conical,circle-involute,cornu,daisy,epispiral,
            archimedian,fermat,nielsen,ulam,poinsot,phyllotaxis]
       helix<!a curve for which the tangent makes
            a constant angle with a fixed line>
       spiral.parameters[center-point,number-of-rotation,
            number-of-band,starting-radius,points-per-rotation,
            growth-per-rotation(horizontal,vertical)]
    </def spiral>
       spring<!simple iteration>
       swarm<!moveable homogeneous population with variable density>
       bunch<!nonmoveable homogeneous population>
       circle[edgeCircle<!population on the edge>,
            insCircle<!population on the surface>]
       elipse[surElipse, edgeElipse]
       cylinder[edgeCylinder,insCylinder:tunnel]
            edgeCylinder<!population on the edge of Cylinder>
            insCylinder<!population inside of cylinder>
       triangle<!ayout defined by 3 factors always existed and related together>
       container<!trunk, regular 3-dimensional figure)
       blackhole<!"off the face of the surface">
       wormhole<!place injected with foreign/strange information>
       free space<!no limits, no predefined structure)
       line[single,multiline]
       curve[parabola,hyperbola,….]
       point<!something that may exist only as a single event e.g. big bang>
            objPoint<!single event for a given object e.g. birthday>
       solids[sphere,cone,pyramid,cube,cylinder]
       polygons[rectangle,square,pentagon,hexagon,octagon]

</def kernel>