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1. Tipalo overview

a. location

in Wollerau, near Zurich, Switzerland; formation in May 2013

b. website

www.tipalo.com

c. trademark

Tipalo is a registered trademark of Tipalo LLC, for:

- 1. Humanoid robots with Artificial Intelligence**
- 2. Design and development of computer software**

d. description

Tipalo GmbH is a Swiss LLC, while the name is an abbreviation for Time based pattern logic.

We are a start up IT company, with own hardware + software, to pioneer logic applications.

We develop a new IT technology for machine based logic using an own self-learning mechanism.

The complexity of our neural net based software is the equivalent of an Artificial Nervous System.

e. AI product

Biologically inspired general-purpose AI --> a digital brain with an Artificial Nervous System

f. AI milestones

2000-2003

papers as theoretical background, see [technology overview](#) for download

April 2019

start of AI development using FPGA boards with HBM2

estimated 2021

a prototype to be used as feasibility study for the unique and complex Tipalo approach, consisting of:
the **operating system** OP-L1, a **generic ANS-L1** and a corresponding **body**,
as a **hardware framework** equipped with **sensors, actors** and internal **organs**.

2. AI approaches

a. biological intelligence

In biology, **tissue is a group of similar cells** that together carry out one or more specific functions called specialty.

Furthermore, **tissue is a cellular organizational level between cells and a complete organ.**

Organs are then formed by the functional grouping together of multiple tissues, each with own specialty.

This also applies to **biological neural networks**, where the similar cells are specialized cells called neurons.

b. assumptions

- Biological neural networks have inspired the design of artificial neural networks as digital representation in a computer, but these are not strict copies of their biological counterparts, because there are limits regarding their implementation.
- **What entry point is feasible enough to represent the needed functionality? Atoms, molecules, cells or only the math?**
- **We assume neural nets are the basis for logic, but use only digital neural nets, which do not change interactively**

c. problems

- **AI is difficult and complex**, because, even if we know today how a single biological neuron is working on its own, **there is no explanation how biological neural nets are creating and developing higher forms of organization**

d. goals

- **the development of a general-purpose AI is the ultimate goal, in order to reproduce the functionality of a (human) brain, then used as a template for creating digital brains with various skills and knowledge, fit to adapt for multiple purposes**

e. common AI approaches

There are many approaches as how to implement biological neural nets in digital computer systems, but

unfortunately there are no breakthrough findings or solutions, which can reproduce their functionality.

Hereby some of them:

- **mathematical approach** machine learning using computational statistics, specific use for a well-defined task
this approach is commonly used, however the neural nets do NOT change in time
https://en.wikipedia.org/wiki/Machine_learning
- **academic approach** simulation of the mouse brain using supercomputer
this approach is used for R&D, due to the enormous capacity needed
<https://www.epfl.ch/research/domains/bluebrain/blue-brain/about/>
- **application approach** dedicated models to be used in specific areas of expertise
DARPA AI next campaign, USD 2 billion project for the next generation AI
<https://www.darpa.mil/work-with-us/ai-next-campaign>
examples of topics for developing dedicated models
Lifelong Learning Machines (L2M)
<https://www.darpa.mil/program/lifelong-learning-machines>
Explainable Artificial Intelligence (XAI)
<https://www.darpa.mil/program/explainable-artificial-intelligence>

3. Tipalo AI approach

a. multiple domain sources

Technology semiconductor, hardware, software, programming languages, databases

Science physics, chemistry, cytology, genetics, biology

Organism histology, embryology, anatomy, physiology, neurology

Behavior psychology, sociology, history, mythology, economics

Thinking logic, philosophy, linguistics, pedagogy, ethics

b. procedural method

Our principle is: “**Many small things, which react permanently with each other in a space, build together in time a large object**”.

This bottom-up approach connects neurons on demand to build higher forms of organization, as a net of connected neural nets.

This hierarchical model implements various net types, with a **self-learning mechanism enabling their change in time interactively**.

c. result

An embedded system with body and self-learning brain, which can explore autonomously its environment, is a living machine.

The **digital brain** with an **ANS, Artificial Nervous System**, is to be used in conjunction with a **body framework** consisting of:

- **sensors**, e.g. video, pressure, gyro, etc.
- **actors**, e.g. limbs with servos, head with sensors and servos, etc.
- **internal organs**, e.g. rechargeable battery, etc.
- **skin**, as delimiter with optional sensors, e.g. pressure, etc.

4. Tipalo AI Technology

a. hardware

FPGA in combination with HBM2 and Optane DIMM, while using only Ethernet as external interface

- **FPGA** enables massive parallel processing with high capacity + low processing frequency + strong encryption
- **HBM2** is volatile memory with high bandwidth + high capacity + low power consumption, builds system-in-package with FPGA
- **Optane DIMM** as persistent memory with high bandwidth + high capacity + low power consumption + strong encryption
- **Ethernet interface** is the network standard for bidirectional connectivity, including the World Wide Web, also known as Internet

b. software

- **real-time operating system, implemented in VHDL for FPGA as encrypted bitstream**

- executing **SP-NN, Self-programmable Neural Nets**, as follows:

access input signals on-demand, process them according to own specialty and generate output signals to other(s)

being able to adapt themselves to emerging necessities by self-programming their internal and external connectivity

- running **SP-NoC, Self-Programmable Networks on chip**, to enable communication between neural nets by connecting

the SP-NN among themselves, in order to build applications

applications among themselves, to build the ANS

- **software package, implemented as ANS, for encrypted storage of binary files in Optane DIMM**

applications, for simulating various brain regions, including **neural drivers applications** for sensors, actors and organs

self-learning mechanism, for storage and retrieval of accumulated knowledge, obtained via own experience or from others

Operating system for general-purpose AI

Features

- a. **hardwired**, written exclusively in VHDL for FPGA SiPs containing HBM2 memory, e.g. Xilinx XCVU37P
- b. **massive parallel processing**, for executing exclusively Tipalo dedicated self-programmable neural nets
- c. **self-programmable dedicated networks on chip** - connecting all neural nets including the i/o neural drivers
- d. **real-time**, enabling human-alike reaction times, e.g. 1ms for all simultaneously active neurons
- e. **made for embedded systems**, requires a connectivity to sensors and actors of a corresponding body

Components

- a. **applications**, as brain areas/regions with multiple neural nets connected to an ANS
- b. **support for self-learning mechanism**, which is implemented as the interaction between neural nets
- c. **Interfaces**, for Ethernet only, as 10/100/1000 Mb, **10/25/100 Gb only starting with OP-L2**
- d. **support for HBM2**, to be used for storing kernel applications, **only starting with OP-L2**
- e. **support for Optane DIMM**, to be used for storing accumulated knowledge, **only starting with OP-L2**

ANS support

- a. **configuration**, as place + route + connect + activate all neural nets within the ANS
- b. **support for modes**, execution pause for certain period of time, on/off switch for self-learning mechanism, etc.
- c. **support for encrypted storage**, means the entire ANS is stored internally and encrypted
- d. **upload/download**, via Ethernet interfaces, **only for development purposes**
- e. **debugger**, as debug, trace and log neural net activities via Ethernet interface, **only for development purposes**

ANS - Artificial Nervous System

1. **requires operating system OP for general-purpose AI**
2. **neural drivers**, for connected sensors, actors and internal organs of an embedded system
3. **neural nets**, as applications, which simulate various brain regions
4. **self-learning mechanism**, integrated within the neural net application framework
5. **accumulated knowledge**, with storage and retrieval of information according to situation

5. Tipalo AI classification

There are 3 different levels of intelligence, we have the following **bottom-up hierarchical classification**, where, in terms of neuronal capacity, each level is ca. 100 to 1000 times higher than the previous level:

ANS level 1, corresponds to insects, enables the following skills:

- simple sensor input drivers, allows perception of different element
e.g. visual black+white, etc.
- simple actor output drivers, allows commands of simple actions of body limbs,
e.g. locomotion with small speed, etc.
- simple glue logic, allows pre-defined reflexes for processing as input to output connectivity
e.g. fixation on sensor element with certain attribute(s) and follow the trail accordingly
- internal connectivity, between body components and sensors + actors
e.g. sensors + actors + internal organs
- self-learning mechanism, allows user-defined connectivity between different parts of the ANS
e.g. memory and connectivity of certain parameters

Usage

It consists of the operating system OP-L1, a generic ANS-L1 and a corresponding hardware body.

This is a prototype to be used as feasibility study for the unique and complex Tipalo approach.

ANS level 2, corresponds to mammals/fishes/birds, enables the following skills:

- complex sensor input drivers, allows perception of objects
e.g. color visual as RGB
- complex actors output drivers, allows commands of complex body actions,
e.g. locomotion with different speed, sense of balance, coordination of own body parts, etc.
- memory, means storage of many and different objects and landscapes
e.g. objects can be grouped, which allows a classification based on user-defined templates
- complex glue logic, allows multiple pre-defined own status quo induced by situations
e.g. situation triggers imminent danger caused by a crowded landscape
- self-learning mechanism, allows user-defined behaviour based on multiple factors
e.g. analysis of a situation with different objects within a certain landscape

Usage

It consists of the operating system OP-L2 and a generic ANS-L2 for a corresponding hardware body.

This will enable autonomous pilots for different vehicles, such as:

- **terrestrial**, e.g. cars, trucks, heavy-duty vehicles, etc.
- **naval**, e.g. boats, yachts, ships, etc.
- **aero**, e.g. UAVs, planes, high-altitude pseudo satellites, etc.
- **space**, e.g. low earth orbit telescopes, high earth orbit satellites, deep space robotic spacecrafts, etc.

ANS level 3, corresponds to primates, enables the following skills:

- little language processing, assuming 2 different pre-defined specific applications
e.g. center for speech interpretation, center for speech production
- accumulation of knowledge, by using amongst others also some language processing
e.g. physical, logical and abstract terms for building and using an user-defined dictionary
- imagination, requires retrieval on demand of memorized objects and landscapes
e.g. internal representation and processing of possible scenarios
- complex logic processing, which includes selection and association of terms and actions
e.g. physical, logical and abstract terms for building and using an user-defined encyclopedia
- self-awareness, recognition of own body within the internal representation of perceived objects
e.g. proved via the mirror self recognition test

Usage

It consists of the operating system OP-L3 and a generic ANS-L3 for a corresponding hardware body.

This will enable robotic workers of different shape, size and structure.

Remarks

1. Some animal species are self-aware, means recognizing themselves in a mirror
 - e.g. mammals like elephant, bonobo, birds like Eurasian magpie, fishes like cleaner wrasses, etc.
2. Self-aware does NOT mean free will
3. Free will does NOT imply one has an inconsiderate and aggressive behavior towards the entire world

6. Tipalo AI roadmap

a. Products

A product with the intelligence level 1 is estimated to be available in 2021.

It consists of the operating system OP-L1, a generic ANS-L1 and a corresponding hardware body. This is a prototype to be used as feasibility study for the unique and complex Tipalo approach.

A product with the intelligence level 2 is in development.

b. Custom-design

products development of digital brains with different capacity, skills and knowledge

services accessing cloud based digital brains for different purposes, e.g. as remote control of certain body hardware

c. Cooperations

a. with hw manufacturers to support hw drivers in operating system

b. with hw manufacturers to develop new hw as sensors, actors, internal organs

c. with hw manufacturers to develop new hw for body framework

 e.g. vehicles of all kind

d. develop ASIC / SiP as FPGA replacement using different semiconductor technologies

 e.g. 22FDX, 3DSOC, NRAM, NEM switch, etc.