1. Tipalo overview

a. location

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

b. website

www.tipalo.com

c. 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.

d. trademark

Tipalo is a registered trademark of Tipalo LLC, for:

1. Humanoid robots with Artificial Intelligence

2. Design and development of computer software

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 MVP, minimum viable product, as a 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. 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.

- **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

Hereby some general information regarding the background of AI development.

b. 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.

c. 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**

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. 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

f. Why is it so difficult to develop a general-purpose AI?

Theoretical concepts

Math is a toolbox, based on attributes we can count in physical space, using certain units of measurement, single or combined

Measurement implies everything we can put into numbers is linear, same like moving step by step along a line, back and forth

Biological intelligence is located in a living brain, where each neuron acts non-linear, no numerical order of any feature we know

AI requires a living organism, which has to develop in time to accumulate knowledge by exploring its environment via own experience

The industry

With math we can not measure intelligence, let alone describe its structure, while being alive does not count as a physical attribute

If AI would be a spaceship, people use it as passengers for a cheap journey, but to design it from scratch is difficult and expensive

AI development requires a long-term strategy, contradicting the purpose of private equity, seeking only the fast return of investment

But without math, massive long-term funding and a theory, companies have great difficulties in offering a commercial AI product

Explaining AI

Today, most companies use the term AI, even if in fact they utilize only statistical methods to create large databases

AI means Artificial Intelligence, but until today, there is no definition of what intelligence even is, biological or other forms

If human intelligence can be digitally reproduced, then intelligence should be portable in both ways, from human to AI and back

Under these circumstances, we urgently need to reassess the value and social impact of intelligence, as it would affect everybody.

Conclusion

AI is difficult, complex and depends heavily on deep interdisciplinary knowledge from many known sciences,

using exclusively math is unilateral, instead it requires another way of thinking, extending the common linear rules,

First understand the basic principles, afterwards develop a corresponding theory about biological intelligence,

at the end create a new technology, from inception via prototype to production, overcoming many social hurdles.

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”**.

e.g. different atoms form a molecule, which on their side form a protein. In our case, **various neuron types are the building blocks**.

This bottom-up approach connects and activates neurons on demand, building pattern logic and higher forms of organization.

The hierarchical model creates versatile net types, with a self-learning mechanism enabling their change in time interactively.

c. result

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.

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

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. r**equires 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:

- max. capacity of the ANS is 1 million neurons, 1 M cells
min. number of connections between neurons is 16 ties/cell

- simple sensor input drivers, allows perception of different element
e.g. visual black+white, gyro, pressure, 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 an embedded system with the operating system OP-L1, a generic ANS-L1 and a corresponding hardware body.

This is a MVP, minimum viable product, to be used as a study for the unique and complex Tipalo approach.

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

- min. capacity of the ANS is 1 billion neurons, 1G cells
average number of connections between neurons is 256 ties/cell

- complex sensor input drivers, allows perception of objects
e.g. visual color as RGB, audio, gyro, pressure, etc.

- 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

- medium 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:

- min. capacity of the ANS is 10 billion neurons, 10G cells
average number of connections between neurons is 1024 ties/cell

- 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 among 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 road map

a. Products

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

It consists of an embedded system with the operating system OP-L1, a generic ANS-L1 and a corresponding hardware body.
This is a MVP, minimum viable product, to be used as a 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. Cooperation

a. with hw manufacturers to support sw 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. with various companies to develop ASIC / SiP as FPGA replacement using different semiconductor technologies

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