

*«Intelligence creates knowledge,
imagination heralds the future.»*



**DIGITAL BRAIN WITH
ARTIFICIAL NERVOUS SYSTEM**

WHAT ARE THE GOALS OF ARTIFICIAL INTELLIGENCE?

BRAIN FOR BODY

To develop a self-learning digital brain based entirely on neuromorphic neural networks, aka spiking, with a predefined number of neurons to perceive and control a body with sensors, actors and organs, while autonomously exploring its environment with different landscapes, on its own and also with others, acquiring new knowledge through its own experiences and being able to perform certain tasks, alone or in a group.

EXPECTATION

Firstly physical skills like locomotion and carrying a payload, secondly mental abilities like orientation within the home base and outdoors, communication with others of the same species, teaching others by passing on information in a certain way, e.g. the waggle dance of honeybees having brains with "only" 1 M neurons.

The power consumption should be near to that of a corresponding biological brain.

TEMPLATE

The underlying theoretical model should be extensible to allow adaptation and development of specific features, and it should be scalable to a much higher number of neurons, e.g. 1K or even 1M times higher overall capacity.

It should use dynamic resource allocation, allowing "only the knowledge needed" to be used in a given context, with the feature of explaining what, where and why each piece of information was processed, stored or retrieved.

TIPALO AI TECHNOLOGY

AI APPROACH

Tipalo GmbH is a Swiss LLC near Zurich, an AI startup with own software to pioneer logic applications.

The Tipalo approach to AI is very simple: we take biological intelligence as a template, means the living brain.

It needs a different mindset to comprehend and represent parts of the real world and replicate the human mind.

Our understanding of intelligence is based on logic, our AI concept contains objects reacting in time and space.

AI IMPLEMENTATION

Tipalo AI enables the simulation of different brain regions in real-time, all the time and stand alone,

while being connected to a certain body hardware, which is equipped with sensors, actors and organs.

The VHDL implementation of our AI model allows massive parallel execution, without any processors.

This implies we do not use any math/statistics/algorithms, while no bias/training/inference is required.

AI COGNITION

The mental process of acquiring knowledge and understanding through thought, experience, and the senses.

Cognitive processes use existing knowledge and discover new knowledge via own experience."

Cognition requires memory and working memory, perception, attention, processing of information.

Cognition presupposes an own embedded self-learning mechanism, which connects information to knowledge.

COGNITION - 10 GENERAL FEATURES USED IN TIPALO AI TECHNOLOGY

BRAIN

1. **Cognition is a function of the brain, hence it requires a body with sensors, actuators and organs.** Perception requires sensors, e.g. camera for images, action needs actuators, e.g. limbs for locomotion, while organs define the own needs, e.g. hunger for energy in order to stay «alive».
2. **The building block of the brain is the neural net, which can have different functionality as specialty,** which on its side consists of neurons connected via synapses, also called spiking cells with ties.
3. **The neural networks must all execute simultaneously in real-time, all the time and stand-alone.**

NEURAL NETWORKS

4. **The neural networks can have either a predefined or a user-defined connectome,** having the ability to form new connections between the cells and also between neural nets.
5. **There are pre-defined neural nets to interface with the body components,** to transform external signals into information and viceversa, for each type of sensor, actor and organ.

KNOWLEDGE

6. **The entire knowledge, pre-defined or accumulated, consists of different specialized areas of knowledge.**
7. **A knowledge area would consist of specific types of neural nets:**
a neural processor of information with an own self-learning mechanism, a log used as a working memory and a long-term memory to store and link the information as a self-associative memory.

ARTIFICIAL NERVOUS SYSTEM

8. **The different areas of knowledge together with the drivers will form the Artificial Nervous System.**
9. **The ANS begins like any newborn, with a minimum of predefined knowledge known as genetic inheritance.**
10. **The number of neurons remains the same from the begin to end of life, only the knowledge is extended.**

Tipalo AI - building block for cognitive AI

The FPGA board is the hardware equivalent, the operating system is in charge of processing the PNNs, the ANS represents the connectome of all contained neural nets, including their configuration and mappings. This building block is used to implement the digital brain, for both cloud AI as well as edge AI. Depending on the implemented ANS, 1 or more FPGA boards are needed in order to fulfill the requirements.

DESCRIPTION

1. FPGA board with high capacity and embedded HBM2 memory
2. VHDL real-time operating system Tipalo OP-L2, to manage brain region(s), beta release
3. Artificial Nervous System Tipalo ANS-L2, with cognitive features as PNN, Programmable Neural Net, beta release

COGNITIVE FEATURES

1. DPE, Dedicated Processing Engine, with SLM, Self-Learning mechanism
2. LOG, as temporary memory used to hold the relevant information for a certain period of time
3. SAM, persistent memory as Self-Associative Memory

ARTIFICIAL NERVOUS SYSTEM

1. SID, Sensor Input Drivers, to convert the external signals from sensors into information, e.g. camera
2. IOS, Internal Organ System, to connect the organs bidirectionally with the brain, e.g. energy source
3. ACD, Actor Command Driver, to convert information into commands for complex ac(tua)tors, e.g. limbs
4. MGL, Medium Glue Logic, contains areas of specialized knowledge, each with own cognitive features

First, the FPGA boards are connected to the corresponding body hardware with sensors, actuators and organs, then the genetic knowledge is uploaded from encrypted binary files, and the AI system is ready for use. The acquired knowledge during lifetime can be regularly downloaded, for evaluation, analysis, debugging, etc.

Tipalo AI - building block for cognitive AI

This building block is used to implement the digital brain, for both cloud AI as well as Edge AI.
Depending on the implemented ANS, 1 or more FPGA boards are needed in order to fulfill the requirements.



Tipalo AI - implementation as cloud AI

The implementation for a cloud AI requires a framework build on cloud infrastructure.

1. servers for administration, configuration and maintenance of the distributed connected devices using TCP protocol
2. real-time application(s) as cloud AI using UDP protocol, located in the FPGA boards connected to the servers
3. additional software used for AI traffic analysis and evaluation purposes, implemented as separate server applications

CLOUD AI APPLICATION

1. AI building blocks as FPGA boards with high capacity and embedded HBM2 memory
2. software for administration and configuration of the AI connectome, for up- and download of the ANS knowledge
3. real-time functionality as cognitive AI with areas of knowledge, using certain configuration for connected hardware

CLOUD AI SERVICES

1. cloud AI for automation purposes, e.g. digital managers for connecting sensors and actors for intelligent solutions
 - a. smart buildings
 - b. industrial processes
2. digital brains for telepresence, e.g. various robot types engaging in different landscapes and environments
 - a. pilots for autonomous vehicles, e.g. internal traffic for industrial zones
 - b. robotic workers for enclosed facilities, e.g. manufacturing and production lines
3. digital brains for knowledge management, e.g. administration of the knowledge development in time
 - a. initial basic knowledge, for all components within the given implementation
 - b. accumulated knowledge, database for storage and retrieval as well as updates for consolidation and distribution

Deploy

Products & services

Edge AI - products

Cloud AI - services

telepresence + evaluation

Colony AI - combined Edge AI + Cloud AI

Usage

different levels of intelligence,

as single AI or group of AIs

L1 - managers for smart buildings

L2 - pilots for autonomous vehicles

L3 - robotic workers for outer space tasks

Intelligence

levels as biological equivalent

capacity as max. amount of neurons

L1 - insects, 1M cells

L2 - mammals/fishes/birds, 1G cells

L3 - primates, 10G Cells

Evaluation

Reports, by hour/day/week/month for
information by knowledge areas updated

via own experience

shared, with / from others

for all activities, sorted by tasks

Tipalo AI technology

DIGITAL BRAIN WITH
ARTIFICIAL NERVOUS SYSTEM
for buildings, vehicles and robots
with sensors, actors and organs

Features

Real-time autonomous AI

Self-Learning

Genetic Memory with knowledge areas

Accumulated knowledge via

own / shared experience

Background

Space-time-matter continuum

Space as neighboring cells

Time flow for matter to act + react

Matter = basic components (re)combining

Objects as connected components

Development

IDE + VHDL for FPGA-SoC with HBM2

Components IP as neural nets

PNN - Programmable Neural Nets

SLM - Self-Learning Mechanism

SAM - Self-Associative Memory

Libraries

ANS - Artificial Nervous System, with
neural drivers for sensors/actors/organs

neural apps, e.g. ID, locomotion, tasks

neural storage, e.g. STM / MTM / LTM

Short-/ Mid-/ Long-Term Memory