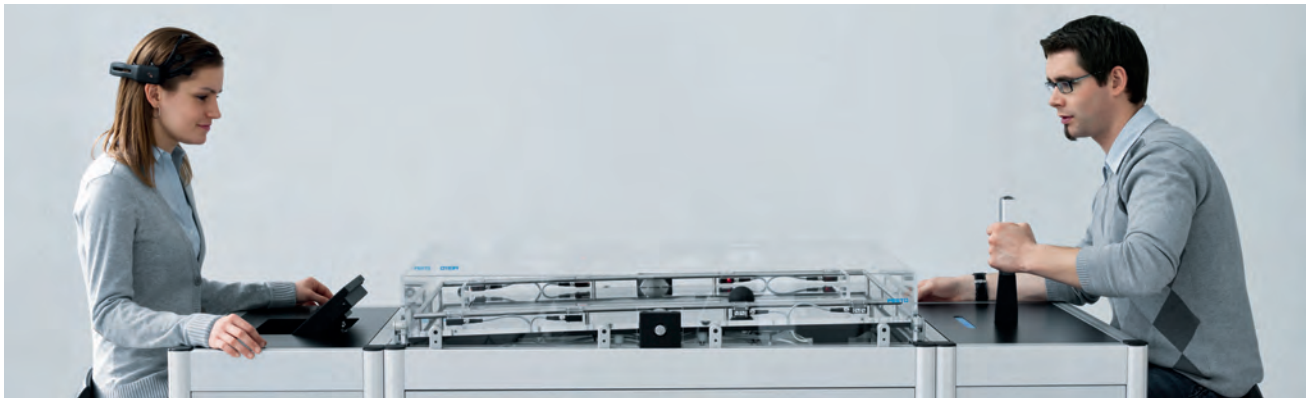
CogniGame

Control by the
power of thought

New operational concepts for human-machine interaction



GogniGame is a reinterpretation of a table tennis simulation game, which was launched on the market in the 1970s. As in table tennis, the players used a joystick in order to move a bar up and down the screen to hit a ball back to their opponent. If a player did not manage to hit the ball, his opponent was awarded a point.

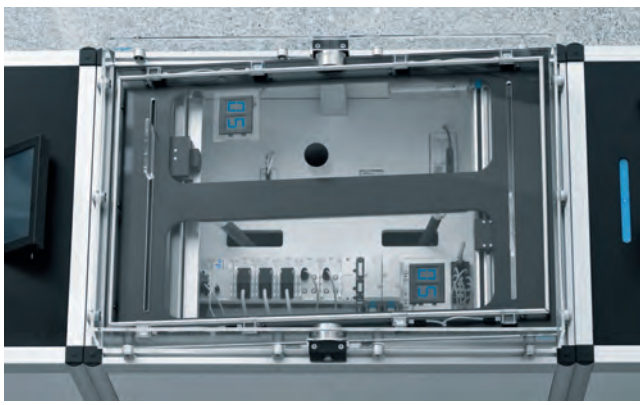
Realistic action
For CogniGame, the development team transferred the virtual computer game to a real playing field that is composed of components from Festo. Two linear axes with drive units that move along the baseline operate the bat, which strikes the ball in order to keep it in play.

Cognitive control
By means of a brain-computer interface (BCI), a player uses only his power of thought to control the bat. As in electroencephalography (EEG), this interface measures voltage fluctuations on the player's scalp by means of affixed electrodes. On the other side is a second player, who uses his muscle power to operate a lever that moves his own bat.

For this game Festo developed CogniWare, a software solution that controls the bat by means of thoughts and biological signals. It establishes a communication channel between the brain and the hardware, without the user having to interact by means of voice commands or input devices. The brain-computer interface and the CogniWare software register the thought patterns in the player's brain, process them and convey them to the hardware.

Already a reality: touchscreen and voice input
Modern interfaces such as multi-touch operation and voice control of consumer devices have already proved successful in everyday life. Already today, people can control their hi-fi systems or car air conditioning unit by voice commands or tell their smartphones who they want to contact.

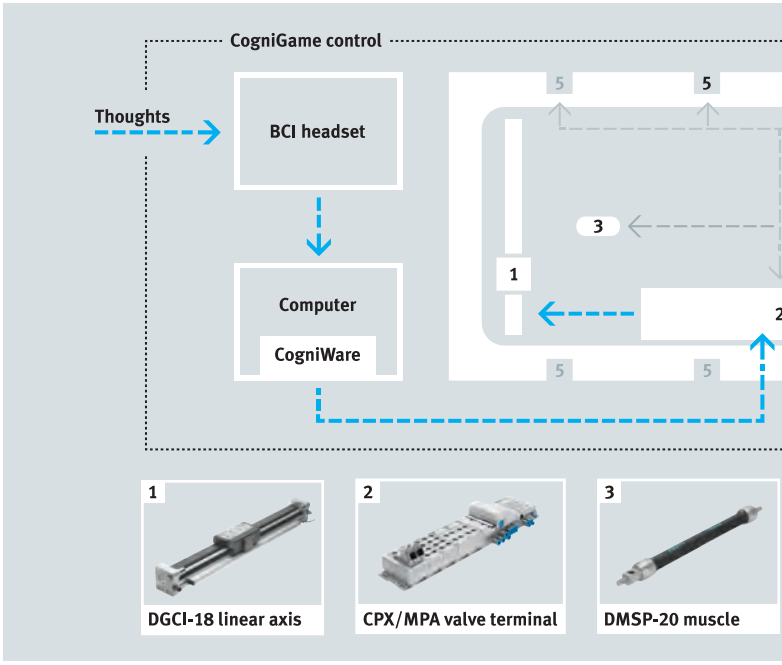
The next generation: brain-computer interface
The brain-computer interface represents the next generation of human-technology interaction. With CogniGame, Festo is demonstrating this new operational concept, which will be of interest for the automation industry in the future.



CogniGame: the virtual computer game transferred …

… to a real playing field with cognitive control

Control by the power of thought with the brain-computer interface



Intelligent interaction between components: from the brain-computer interface and software,

Precise control of all drive units

A CPX /MPA valve terminal from Festo ensures precise control of the two linear axes. A DGCI-18 servopneumatic axis is controlled by the player with the brain-computer interface. His opponent, on the other hand, operates an EGC-50 electrical axis by activating the lever. The two axes behave identically and can be moved to the left or right, in order to prevent the ball from reaching the baseline. The sensors embedded in the playing field determine the position of the ball and award points accordingly.

The ball is constantly kept in motion by means of tilting the playing field. The speed of the game can be modified by adjusting the tilt angle. For this purpose, two DMSP-20 pneumatic muscles are affixed to the underside of the field. The angle of tilt can be precisely metered by means of the integrated proportional technology of the VPPM valves.

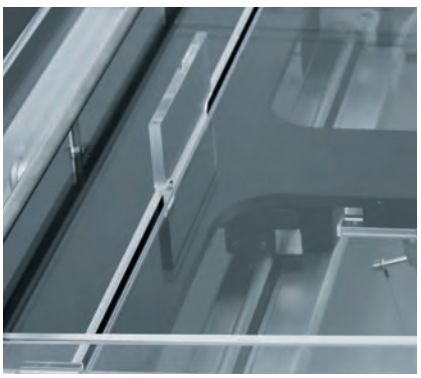
The key to the development of CogniGame, however, was the specially devised CogniWare software from Festo. It comprises the link between the brain-computer interface and the hardware.

CogniWare: interface between the player and the game

The interface is coupled to the software and activates a linear axis by means of thought control. For CogniGame, the developers from Festo made use of a commercially available brain-computer interface that is fitted out with a total of 14 signal electrodes and two reference electrodes. This interface samples the raw brain signals at a rate of 128 times per second; these signals are then filtered and conveyed to the software.

Operation of the brain-computer interface is made possible by measurement of the “mu rhythm” that is generated in the motor-sensory cortex of the brain as a result of physical movement or even of the mere thought of such movement. It is therefore sufficient to simply imagine the left hand moving, for example, in order to displace the axis to the left.

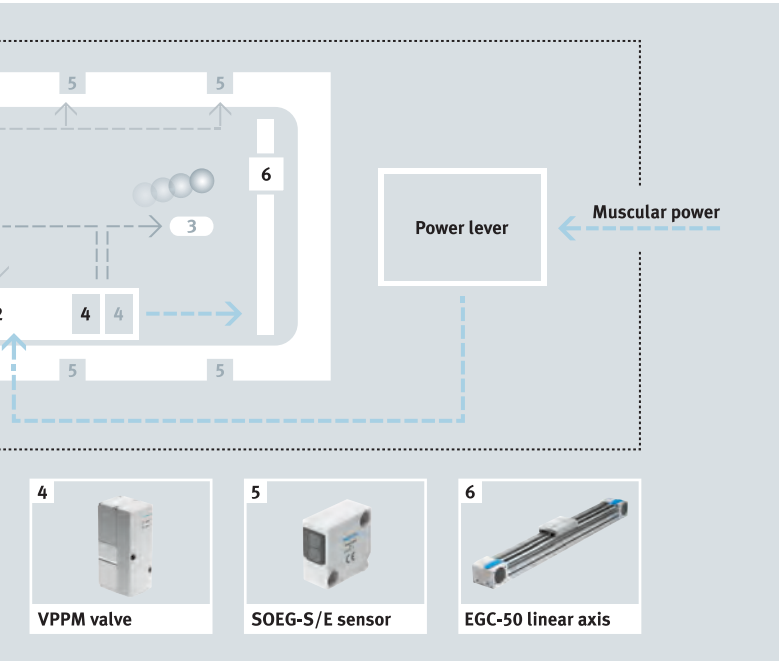
CogniWare now offers the possibility of switching between training and game modes. In training mode, the user is prompted to produce the thought patterns “left” and “right” in order to move his bat in the desired direction.



Controlled by thoughts:
the DGCI-18 servopneumatic axis

Precise control of all components:
the CPX /MPA valve terminal

Pressure control in the pneumatic muscles:
the VPPM valves



via CPX, to the linear axis

Conventional operation with muscular force on the lever arm

The brain patterns are analysed in real time and conveyed to a learning algorithm. This generates a configuration that is adapted to the individual player and is used in game mode. CogniWare recognises a particular action whenever the user reproduces the thought pattern acquired in training in the course of a game.

Full concentration required even in training mode
The more similar a player's thought patterns in training and in a game, the more reliable are the control functions. This does not come easily to all players and requires a great deal of training. At the same time, players should try to keep their facial muscles as relaxed as possible, since the measurements are influenced by all types of gestures and facial movements, so-called biosignals.

In combination with its graphical user interface, CogniWare also determines the course of play by defining the start and the end of the game. This software also controls the speed of the game as well as the degree of difficulty for the opponent, as well as checking the connection quality of the individual electrodes on the player's headset and relaying the commands to the CPX unit.

Development expertise for software solutions
As a technology leader in automation, Festo demonstrates with CogniGame in a playful manner that not only robust and reliable hardware components, but also intelligent software solutions are playing an increasingly important role as competitive advantages in control and regulation technology. Examples include the following:

ASIMON: software for graphical, interactive operation and configuration of security solutions at the AS (actuator-sensor) interface.

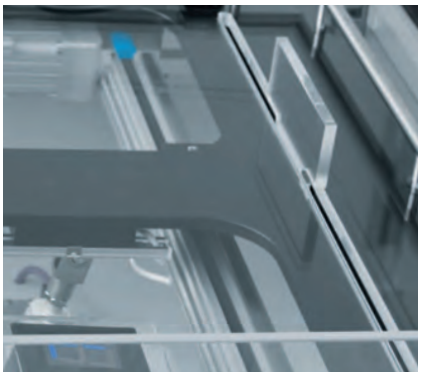
FCT: Festo Configuration Tool for the uniform configuration and parameterisation of all servopneumatic and electric drive units, axes, and motor control units from Festo.

FHPP: Festo Handling Profile, for the uniform setup and programming of all drives via fieldbus/ethernet systems.

CoDeSys pbF: a special version tailored to Festo and automation technology, with an integrated motion control package.

Tilting the field with compressed air:
the DMSP-20 pneumatic muscles

Tracking the ball's position:
the SOEG-S/E sensors on the sidelines



Moved by muscular force:
the EGC-50 electrical axis

The heart of the new operating concepts: software as a channel of human-machine communication

A glance into the future reveals visions that go even beyond mere voice control. Before long, both consumer goods and industrial machinery could also be controlled by means of thought commands. The experts already foresee the use of brain-computer interfaces in the near future, for example in the operation of smartphones or for working on tablet PCs.

A pioneer in the thought control of machines

As an innovation leader in its industry, Festo investigated thought control of machines at an early stage and developed its own software solution for the CogniGame pilot project. This technology is becoming increasingly intelligent and is more and more capable of adapting to changing ambient conditions and adaptively responding to human intervention at all times.

New requirements for the factory of the future

In its investigations into the factory of the future, Festo is concerned with the questions of how humans and machines can interact more efficiently in the face of constant technological change, and the demands that production must meet in the future.

Even in the factory of the future, not all processes will be fully automated. Rather, the production facilities of the future will be characterised by variable processes. New operational concepts will be in demand, with which the human operator can communicate with the technology more rapidly, directly and conveniently: the solutions will range from joystick systems via voice commands to the control of processes by thought.

New concepts in human-machine interaction

Using specially developed software solutions in combination with a brain-computer interface, Festo is carrying out research into thought control of systems in automation.

In the future, software solutions such as CogniWare in conjunction with other systems could extend the human operator's scope of action to meet specific requirements by means of active support. In conjunction with the active ExoHand manual orthosis, for example, applications are conceivable for power amplification in industrial assembly, in the rehabilitation of stroke patients or for the intuitive control of robots.

A possible future scenario: controlling machines by thought

A wide range of applications in combination with other systems

Technical Data

- Height: 95 cm, length: 194 cm, width: 76 cm
- 1 electric linear axis, EGC-50
- 1 servopneumatic linear axis, DGCI-18
- 1 CPX-CEC-C1
- 2 sensors, SOEG-S/E
- 2 Festo muscles, DMSP-20
- 2 proportional valves, VPPM
- 2 7-segment display elements
- Lever unit with force sensor (1000 N)

Computer
- 1 Dell Optiplex 990, Intel Core i5 Processor 3.10 GHz
- Windows 7
- 1 LCD Touchscreen

CogniWare
- Application: .Net 4.0 in C# (WPF interface technology)
- BCI2000 system
- Matlab

- Brain-computer interface. Emotiv EPOC (14 signal electrodes, 2 reference electrodes)
- Channels: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4
- Sampling rate: 128 SPS (2048 Hz, internal)
- Resolution: 16 bits, LSB = 1.95 µV
- Range: 0.2 – 45 Hz, notch filter at 50 Hz and 60 Hz

→ Film

Project partners

Project initiator:
Dr. Wilfried Stoll, managing owner,
Festo Holding GmbH

Project team:
Dipl.-Ing. (FH) Markus Fischer, B. Sc. Nadine Kärcher,
Dipl.-Des. Elias Knubben, B. Eng. Matthias Gehring,
Christian Mangler, Festo AG & Co. KG

Prof. Dr. med. Alireza Gharabaghi, Dr. med. Florian Grimm,
Dr. med. Georgios Naros, Centre for Integrative Neuroscience of the Tübingen University Hospital

Festo AG & Co. KG

Ruiter Strasse 82
73734 Esslingen
Germany
Phone +49 711 347-0
Telefax +49 711 347-21 55
cc@de.festo.com
www.festo.com/group

54795 en 4/2012