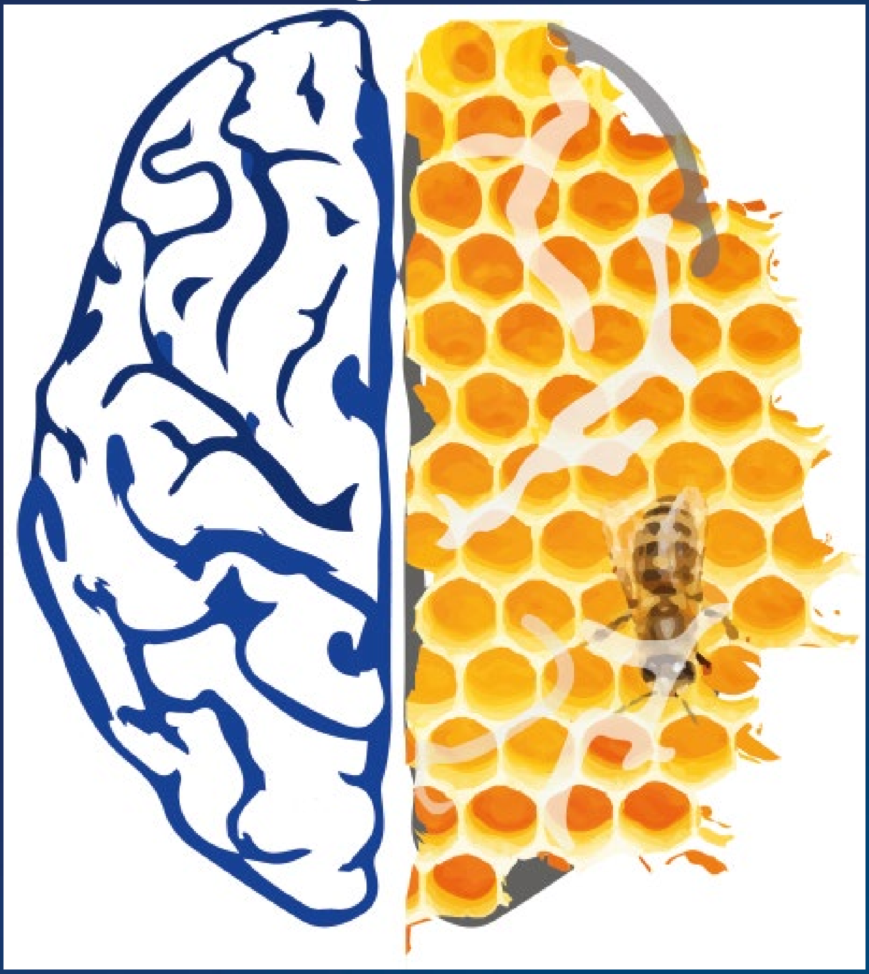
Whitepaper

Swarm intelligence in the world of driving systems



Michael Burgert | Product Manager BLDC Motors
Dunkermotoren GmbH

The beehive is a symbol often used as a paradigm for swarm intelligence: maximum productivity, perfect organization, pinpoint-accurate communication and everyone performs tasks in an independent and autonomous way. Each task is therefore indispensable for the entire organization. Sounds familiar? Quite possible, because these elements are also essential components for an ideal "industry 4.0" world.

Therein, components communicate with each other, they arrange themselves and provide for maximum flexibility which is attended by highest productivity in manufacturing and logistics. As in the beehive, the components monitor themselves as well as their environment. In addition, they compensate external influences.
But what is about the hard-working bees and therefore the components in a modern production line? Are they now ready for autonomous working? As an example, we take a quietly humming electric drive mechanism with integrated electronics, corresponding to the state of the art, and examine it per the following criteria: "Recognizes and compensates environmental impacts," "works autonomously", "communicates" and "monitors itself".

Criterion „recognizes and compensates environmental impacts ":

Environmental impacts are detected by sensors which then give these impacts further to the motor electronics in form of electrical signals. Nowadays it is a breeze for drive mechanisms with integrated electronics to read digital or analog signals and to incorporate them into the process. Position sensors record the actual position and regulate the position again if necessary. Inclination sensors detect deflections through wind and thermal expansion effects in solar applications and regulate the position again. With the aid of compression sensors, drive electronic systems regulate a constant hydraulic pressure. This environmental information is supplied from outside to the drive mechanism. At the same time, there are many more sensors or sources of information which stuck in a modern drive mechanism: The electric current sensors in the motor measure the electric current of the motor, which is a measurement for the mechanical output. If this output is increasing over time although the moving load remains equal, then this could be a reference to the wear and tear of the powered mechanical components. By reading and interpreting the motor electric current, worn mechanical components can be replaced before the actual failure and production stoppages can be avoided. The motor electric current is a component of a pick-and-place system and is therefore a very good measure of the mechanical output. This is why it can detect incorrectly inserted or jammed parts or parts that are too light or too heavy. In addition, it can influence the process in an equivalent manner.
Related to the criterion "recognizes and compensates environmental influences", it is the electric drive mechanism with integrated electronics which scores well. But how is it about autonomous work?

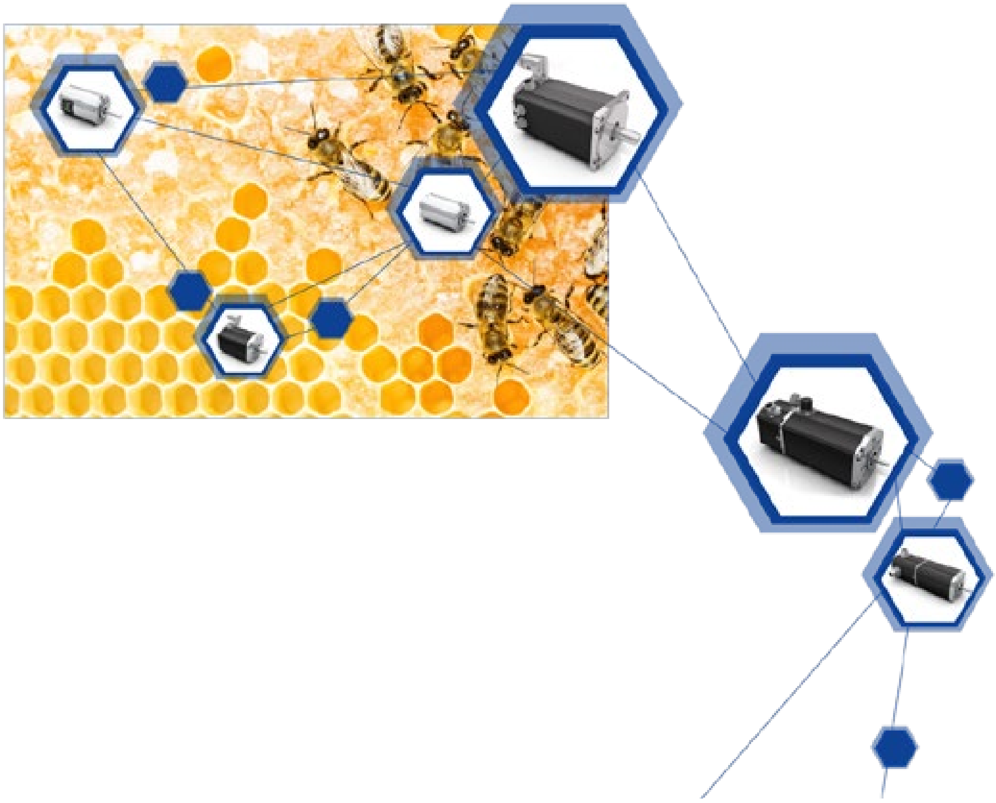
Criterion "works autonomously":

Nowadays motors with an integrated drive mechanism are already able to control small installations autonomously. In a packaging machine, for instance, a drive mechanism gives a command to another drive mechanism. This command could include that the second drive mechanism should tauten the packaging tape with a certain force after the first drive mechanism did detect that the tape has reached the station "tape taut". The detection is managed in the way that the drive mechanism detects the position with the aid of the rise of the motor electric current. So, the individual components pass commands to each other depending on which process state was recognized before. Today this works smoothly in practice. For tasks, which are more complex central controls are still used in general. As processors for integrated drives are becoming more efficient at the same price, more complex tasks can be performed autonomously and increasingly it is possible to

omit entirely central controls.
Integrated drive mechanisms work already autonomously although there is still a huge potential for more complex autonomous tasks. As described, the higher processor performance is a factor. Multiplied by new software algorithms this factor first harness the higher processor performance. According to software, in the future, an enormous potential can be exploited. To stay in the jargon of a bee: „Here is still air above".

Especially the ones who still remember the films from schooldays in which bees communicated information for the food source through dancing know, how essential the **criterion "communication"** is. Without communication drive mechanisms on their own are limited to defined tasks. It is the communication with each other what makes movements coordinated, processes flexible and what allows that an integrated drive mechanism can supply information on its environment. In the simplest case, the environment is a central control. In the future, also every node of a network needs the information about the state of the drive mechanism. For instance, the Maintenance Department can obtain the calculated state of the drive mechanism related to the expected life expectancy, the ERP can determine actual material consumption of the motor data or the Quality Department can derive scrap rates. Totally essential is that the drive mechanism speaks the language of the other nodes. Currently, this is complicated by an almost Babylonian language confusion in digital communication. At this stage, a variety of different fieldbus languages is supplemented by an increasing number of industrial Ethernet versions. Due to integrated "translators", integrated drive mechanisms can already communicate in all common digital languages. However, these translators are inefficient and incur additional costs. A universal digital language, understandable for all network nodes, could therefore save costs and could make networked systems even more efficient.
So, the criterion „communicated" for integrated drive mechanisms can be classified as fulfilled, but there is also potential for improvement as each drive mechanism must lead literally still a dictionary with it and is constantly looking to communicate.

The last criterion which is considered, is **"monitors itself"**. Electronics, integrated in the drive mechanism is matched exactly on this drive mechanism. Even after the drive mechanism has been installed, component and manufacturing tolerances scatters of the drive parameters are determined and software-compensated. Dynamic drive mechanisms calculate the expected warming of the motor and build up magnetic fields in advance. The expected warming can be calculated by motor electric current as well as the angular speed. The magnetic fields are necessary for a specific torque which can be released a few microseconds later. Even slightest deviations from the desired behavior of the drive mechanism can be detected and compensated if physically possible, by this continuous and high-frequency control of all motor parameters. Speed or position deviations, temperature, voltage fluctuations or overload are recognized immediately by the integrated drive mechanism. It compensates it within defined limits and generates an error message in the case that compensation is not possible.
During self-monitoring, the integrated drive mechanism can demonstrate its full strength. According to the extensive measurement algorithms, the drive mechanism monitors itself continuously and thus prevents premature failure. The drive mechanism is able to monitor its environment by reporting unexpectedly high electric currents that indicate there is a component built in wear. In addition, the drive mechanism can read local sensors via its digital and analog interfaces and pass the data to other nodes on the network.



According to the considered criterions, clear parallels result from a network of integrated drive mechanisms and a swarm of bees and therefore, swarm intelligence. Higher processor power will intensify autonomous working in the future significantly and regarding communication, there are promising approaches for a uniform standard. Both improvement potentials make automation systems for manufacturing and logistics more efficient in the future. As in a swarm of bees, whatever more complex tasks can be mastered without the administration of all the information by a central node. Swarm intelligence does therefore not only inspire the honey production but also industrial production!

Your Contact For Public Relations:
Janina Dietsche | janina.dietsche@ametek.com
Phone.: +49 (0)7703/930-546

Author: Michael Burgert
Date: 01.25.2018