Mechatronics in Agriculture

V. Erdélyi¹ - L. Jánosi²

Abstract: Electromechanical systems have been used in agriculture for decades. As technology advances, these devices are increasingly shifted toward mechatronics, since the electromechanical equipment slowly became more and more „intelligent”. In a modern, complex agricultural facility we can find plenty of embedded systems, such as microcomputers, and microcontrollers. These autonomous units are the building blocks of a modern agricultural complex. The basic of today’s modern agriculture is the precision agriculture (PA). Precision Agriculture as a concept appeared in the early ’80-s already. What really interesting is, that the concept of precision livestock farming (PLF) is only little, or not discussed until 2008. This paper try to show the possibilities in precision livestock farming and presents the mechatronic solutions used in the modern agriculture (such as IoT). Discusses the prevailing trends, and also outlines a vision, where livestock technologies are in one network with both the pre and after technologies. With this method the Precision Livestock Farming can be achieved.

Keywords: Agriculture, livestock, mechatronics, IoT, Industry 4.0

1. INTRODUCTION

There was a huge step forward in the agricultural sector, as the Precision Farming appeared (typically in the crop production). Crop production are made more efficient using sophisticated control systems. The essence of precision agriculture is actually the fertilizing and irrigating by needs, and the high precision, minimal overlapping plowing harrowing and planting. For this purpose a lot of IoT (Internet of Things) device are used, such as telemetry, remote sensors, etc. These devices are helping to give real-time information during the farmer’s work. This type of solutions are been know long by the farmers. Interestingly, this degree of control/looped control systems are not used in livestock farming yet. There are sophisticated control systems in certain areas of livestock farming, but they are not, or very rarely connected to a bigger network. The goal of this paper is to outline a system concept and architecture, which allows the Precision Livestock Farming (PLF) to be realized and give further aspects to investigate this field.

2. PRECISION FARMING (CROP)

We can talk about Precision Agriculture since the early 1980s. [1] The precision farming allows the farmer to remotely monitor the soil, the growth state of the plants, the weather conditions on certain fields electronically, and let the farmer intervene accordingly in the system. [2]

2.1 Agriculture and mechatronics

In Precision Agriculture we typically use mechatronic systems to monitor each sub-process, and to control them. These sub-systems are often interconnected. These connections are frequently made by IoT.

2.2 Agricultural IoT (AIoT)

The Internet of Things (IoT) is an umbrella term that covers a variety of typically interconnected network elements, as well as a network of sensors, and which is often uses cloud to compute the enormous amount of data, which is collected. (Cloud Computing, Big Data) [3] In fact IoT is a network between different physical network-compatible devices, and it does not necessarily include humans. [4] We can consider Internet of Things as a new paradigm, not only in agriculture, but in all fields of our life as well. [5] The usage of Internet of Things is widespread in the area of crop production. For example, there are plenty of wireless sensors to measure the moisture of soil, which are located like a grid on the agricultural lands. Or there is a network of weather forecasting stations of various points of some vineyards. But there is also more and more co-working machinery, which can be used for plotting, harvesting, fertilizing or planting precisely, and sometimes automatically. [6]

2.3 Trends

So it can be seen, that agriculture is increasingly shifting towards precise, sophisticated control, which essentially comes with advanced mechatronics.

3. Smart, connected product

Fig 1. Agriculture today (source: Harvard Business Review)
Because this control method requires extensive infrastructure, therefore the amount of wireless solutions also increasing. Egyptian researchers found, that with the use of an extensive sensor system they can reduce the losses in potato yields by about two billion pounds, which are approximately 907'200 metric tons. [7]

The connection is usually implemented with one of the following standard wireless communication protocols:

<table>
<thead>
<tr>
<th>Name</th>
<th>Technology</th>
<th>Price</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>IrDA</td>
<td>Infra light</td>
<td>Cheap</td>
<td>Short</td>
</tr>
<tr>
<td>WPAN</td>
<td>Light/ radio</td>
<td>Cheap</td>
<td>Short</td>
</tr>
<tr>
<td>Bluetooth</td>
<td>2,4 GHz radio</td>
<td>Medium</td>
<td>Mid-range</td>
</tr>
<tr>
<td>ZigBee</td>
<td>784MHz to 2,4GHz</td>
<td>Medium</td>
<td>Mid-range</td>
</tr>
<tr>
<td>multi-hop WLAN</td>
<td>2,4-5GHz radio</td>
<td>Medium</td>
<td>Long-range</td>
</tr>
<tr>
<td>GSM/GPRS CDMA</td>
<td>2G-4G LTE</td>
<td>Expensive</td>
<td>Very long</td>
</tr>
</tbody>
</table>

But why wireless technologies are used? Because the costs of industrial grade wiring are enormous, ca 130-650 US$ per meter, not to mention the maintenance costs. [8]

These measurements and interventions are using mostly Machine to Machine (M2M) communication. That’s because the human usually does not need all that information. The human operator usually gets already processed data, which are often computed in cloud systems. With this processed data the farmer can make decisions in general, or develop automation systems to fully automate the system.

3. PRECISION LIVESTOCK FARMING

The precision agriculture is mainly focused on crop production. Yet in animal husbandry can also be observed some solutions predicting the promotion of livestock farming in the precision direction.

This is not a coincidence, since the animal breeding has countless interlinked processes that are beneficial to be highly automated. By the individual feeding and watering single animals there is an opportunity to trace the individuals, and medicate them uniquely. This, however needs some
in an “Internet of Things” system, where the “things” are the animals themselves. [9] It is necessary to implement these ideas to achieve the individual identification of the animals, which can be done by RFID (Radio Frequency IDentification). [8]

3.1 Tendency
In the development of the Precision Livestock Farming there are some tendencies which can be observed: Modelling of various factors associated with livestock farming, such as growth of animals, manure recycling, feed production (using fertilizers), spatial position. [10] [11] [12]

It seems the ecological role of livestock farming is gaining ground as well.

3.2 Precision Livestock Farming today and tomorrow
Since livestock farms financial situation in Europe has deteriorated due to the CAP (Common Agricultural Policy) program there are some concerns about the non-agricultural utilization of agricultural lands. –This will likely lead to increase of meat prices, and therefore lead to the increase of the importance of Precision Livestock Farming. [13]

Although the main driver of such development project currently is the money [14], there is a noticeable trend, which examines the environmental impact of livestock farms, and would bring that in the foreground. This types of research are examine the odor emissions [15], and the carbon footprint of farms, projected to kilogram, or liter of the product. (Immaculada Batalla, 2015)

3.3 Fears
As all major changes, the shift of agriculture to Cyber Physical space is accompanied by fears. One such fear is the cyber-crime. Obviously, if there is a large amount of data stored, and processed in the cloud, it can come in wrong hands, at least easier, as if all these data would be stored offline, or wouldn’t be stored at all. [16]

The other problem is with this enormous data collecting from various fields, that the data storage and process has to be enormous too. The rapid development of computing technology can’t even keep up with the dramatically increased volume of data. [17] So the solution can be the cloud computing, and cloud storages. (many computers co-operation) [18]

4. PERSPECTIVE INDUSTRIE 4.0?
It is clear that the developers and researchers in agriculture, only apply IoT to solve specific sub-tasks
In the industry, this trends are very different by nature, which can be very perspective in agriculture as well. In the industrial field, which is essentially the same productive sector, the IoT and Mechatronic systems are used to build much larger Cyber Physical Systems (CPS). [19] The foundation of the German initiated development of Industry 4.0 (which is basically an Industrial Internet of Things (IIoT)) is that, that the products are monitored from the suppliers, through manufacturing processes, to the end users, with the use of a “smart” system. [20]

5. CONCLUSION
In this paper such a solution was looking for, where the subsequent sub-processes of livestock farming are interconnected in a larger master system. That can be stated if the consecutive sub-systems are codified, and they can be connected to each other (compatible information contents), then the operation can be optimized in a larger system, and will work more efficiently. The following goals are to be proposed for further investigation to set up a system concept:

• To summarize the pig-breeding related technologies
• Analyze the system structure of the cooperating technologies
• Creation of generalized system principles to allow various sub-systems connect
• Determine the parameters of pig-farming which are measurable or have to be measured
• Build the sub-system models
• Determine the total sensor and actuator needs of pig-breeding
• Develop unified technical modules (Plug and Produce) which allow the sub-systems to be linked to the main system
• Simulate the farm’s operation (with the help of the model) to optimize the process
REFERENCES


Authors addresses

1Viktor, Erdélyi, Institute for Mechanical Engineering Technology, Szent István University, Páter Károly u.1, Gödöllő, Hungary Tel.+36 28 522-000, E-mail: erdely.viktor@gmail.com
2László, Jánosi, professor, Institute for Mechanical Engineering Technology, Szent István University, Páter Károly u.1, Gödöllő, Hungary Tel.+36 28 522-000, E-mail: janosi.laszlo@gek.szie.hu