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APPLICATION OF AUGMENTED REALITY IN DAIRY CATTLE MONITORING

Summary

The aim of the work was to design and implement an application with using Augmented Reality technology for supporting dairy cattle monitoring. This article presents the developed application and conclusions concerning the usage of Augmented Reality generally in agriculture.
***Key words**: Augmented Reality, dairy cattle monitoring*

ZASTOSOWANIE ROZSZERZONEJ RZECZYWISTOŚCI W MONITOROWANIU BYDŁA MLECZNEGO

Streszczenie

Celem pracy było zaprojektowanie i zaimplementowanie aplikacji wykorzystującej technologię Rozszerzonej Rzeczywistości w działaniach wspierających monitoring bydła mlecznego. Artykuł przedstawia wytworzoną aplikację oraz wnioski dotyczące wykorzystania Rozszerzonej Rzeczywistość ogólnie w rolnictwie.
***Słowa kluczowe**: Rozszerzona Rzeczywistość, monitorowanie bydła mlecznego*

1. Introduction to Augmented Reality

Augmented Reality (AR), according to Oxford Dictionary, is a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view [1] and according the Merriam-Webster dictionary is an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device (such as a smartphone camera) [2]. More detailed definition of AR is given by Gartner: AR is the real-time use of information in the form of text, graphics, audio and other virtual enhancements integrated with real-world objects. AR integrates and adds value to the user's interaction with the real world [3]. As many or majority of advanced technologies it was developed for military purposes. And for example, in 1990s at the U.S. Air Force's Armstrong Labs many fighter aircraft heads-up displays showed information about the attitude, direction and speed of the plane, and only a few years later they could show which objects in the field of view were targets [4]. Now AR is more and more popular in nearly all disciplines and in every day life. Very popular example of using AR is IKEA catalog with an application Ikea Place and usage of iPhone or iPad's camera and Augmented Reality technology to show its sofas, desks and other items in your room [5].

Augmented Reality is not a kind of futuristic technology. It can be and is applied in any domain. There are also trials to use AR technology in agri-food sector. Directly on the farm, in the field AR can aid farmers in different ways, especially: to inspect the fields, detect the presence of insects and identify them, and treat them rightly, determine the quality of land for agricultural purposes, help to improve farming both in terms of quality and quantity, provide weather information in real time and reduce much of farmers' time and effort which often get wasted due to nature of weather. AR technology can be applied in the context of farms, field, animals, machines, food production and any other [6]. Some example of using AR technology in agriculture can be found in the work of Apurv Nigam and coauthors [7]. This work concerns AR in insect identification and pest management. Wider overview of AR applications in agriculture is made by Robert Szilagyi and Miklos Herdon in [8].

2. Technical requirements of Augmented Reality

There are a lot of aspects of AR to be discussed but we focus only on technical ones, exactly on display equipment which is very important, maybe the most important in AR. Smartphones' or tablets' cameras are just popular but more and more popular are smartglasses. Smartglasses or wearable computer glasses are part of wearable technology, but it's much broader topic. There are two main kinds of AR systems: marker recognition systems and non-marker recognition. The marker recognition systems need special marker which must be scan or take a photo of it and after recognition the suitable application is launched. Non-marker systems are systems based on GPS (Global Positioning System) signal. Finding the right coordinates launches the additional apps. The demands of display equipment for AR are especially important in the marker systems and these demands are:

- wide range illumination – AR display works in low light (indoors) and in bright light (outdoors),
- positional accuracy – the sign (marker) needs to be in close proximity to its actual location,
- addressable occlusion – transparent or non-transparent marker,

- depth of field – the system needs to have an adjustable depth of field for the augmented reality image to correlate to the real world,
- latency – according to most researchers 10 ms will be acceptable for augmented reality,
- and others like: pixel pitch, proximity and refresh rate.

According to some engineers and technologists AR is the most challenging display technology [9, 10].

3. ARP_Bydło – application for supporting dairy cattle monitoring – software engineering perspective

The application presented in this article, ARP_Bydło application, was developed at the Institute of Biosystems Engineering. The aim of this application was to support dairy cattle monitoring with usage of Augmented Reality and mobile devices like smartphones or tables. In details, the role of the application was to show data about chosen cow from the herd data base. Chosen cow means cow seen in the application's window using smartphone or tablet camera. The developed application was marker-based Augmented Reality and in our case the marker is cow ear tag.

The application was developed according to the software engineering principles. First the functional requirements were defined and described in the suitable tables like the one on Table 1. Fig. 1.

Table 1. Example of the functional requirements of the ARP_Bydło application
Tab. 1. Przykład wymagań funkcjonalnych dla programu ARP_Bydło

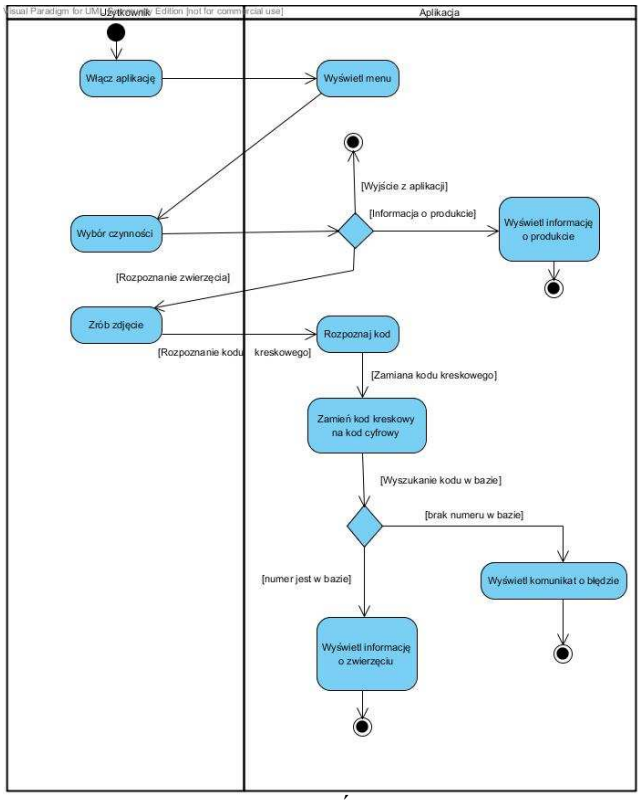
Function name	**Take a picture**
Description	Aim of this function is to take a picture of the cow's ear tag
Input data	-
Source of input data	Smartphone's or tablet's camera
Result	Photo of cow's ear tag in a bit map format
Precondition	Properly working camera
Final condition	-
Reason	The need of an animal's number in electronic form

Source: own work / Źródło: opracowanie własne

Next the UML (Unified Modelling Language) diagrams were created to show the static and dynamic functionality of the application. Example of one of the diagrams, activity diagram is shown on Fig. 1.

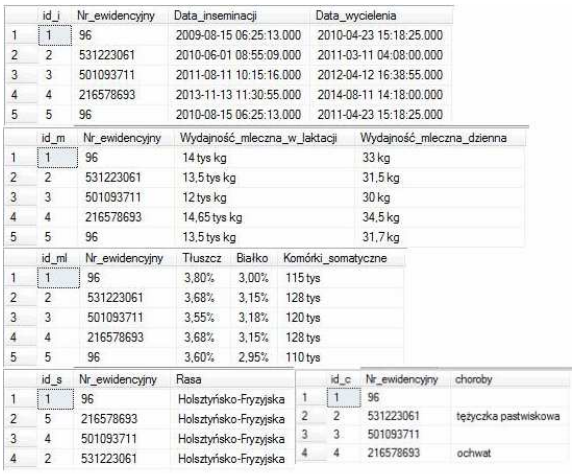
Application was implemented for the Android operational system because according different statistics information this system is the most popular and even will be in some years. It's justified to develop applications for this system.

The application ARP_Bydło was implemented in Java within the IBM Eclipse integrated development environment [11]. The database created in the SQL Server and the SQL language is used to query the database. Examples of database tables and their contents is shown on Fig. 2. The content is typical for dairy cattle, there are basic data like milk fat, milk protein, milk production, date of last insemination or info about veterinary treatment.



Source: own work / Źródło: opracowanie własne

Fig. 1. UML activity diagram for the ARP_Bydło application
Rys. 1. Schemat aktywności UML dla programu ARP_Bydło



	id_i	Nr_ewidencyjny	Data_inseminacji	Data_wycielenia
1	1	96	2009-08-15 06:25:13.000	2010-04-23 15:18:25.000
2	2	531223061	2010-06-01 08:55:09.000	2011-03-11 04:08:00.000
3	3	501093711	2011-08-11 10:15:16.000	2012-04-12 16:38:55.000
4	4	216578693	2013-11-13 11:30:55.000	2014-08-11 14:18:00.000
5	5	96	2010-08-15 06:25:13.000	2011-04-23 15:18:25.000

	id_m	Nr_ewidencyjny	Wydajność_mleczna_w_laktacji	Wydajność_mleczna_dzienna
1	1	96	14 tys kg	33 kg
2	2	531223061	13,5 tys kg	31,5 kg
3	3	501093711	12 tys kg	30 kg
4	4	216578693	14,65 tys kg	34,5 kg
5	5	96	13,5 tys kg	31,7 kg

	id_ml	Nr_ewidencyjny	Tłuszcz	Białko	Komórki_somatyczne
1	1	96	3,80%	3,00%	115 tys
2	2	531223061	3,68%	3,15%	128 tys
3	3	501093711	3,55%	3,18%	120 tys
4	4	216578693	3,68%	3,15%	128 tys
5	5	96	3,60%	2,95%	110 tys

	id_s	Nr_ewidencyjny	Rasa
1	1	96	Holsztyńsko-Fryzyjska
2	5	216578693	Holsztyńsko-Fryzyjska
3	4	501093711	Holsztyńsko-Fryzyjska
4	2	531223061	Holsztyńsko-Fryzyjska

	id_c	Nr_ewidencyjny	choroby
1	1	96	
2	2	531223061	tężyczka pastwiskowa
3	3	501093711	
4	4	216578693	ochwat

Source: own work / Źródło: opracowanie własne

Fig. 2. Examples of data base content
Rys. 2. Przykłady zawartości bazy danych

The dedicated database was created for the purposes of the ARP_Bydło application. It is possible to load different, existing database in order to assure the cooperation with existing herd management system. It was assumed that ARP_Bydło is to expand.

4. ARP_Bydło – application for supporting dairy cattle monitoring – end user perspective

ARP_Bydło application was developed for the smartphones or tables with Android operational system. The main menu of application is shown on Fig. 3.

Source: own work / Źródło: opracowanie własne

Fig. 3. Main menu of ARP_Bydlo application
Rys. 3. Główne menu programu ARP_Bydło

To show the data about chosen cow, the user must run the application and choose the option „Rozpoznawanie automatyczne" (automatic recognition) from the main menu. This option let to see the cow and its ear tag through the smartphone's camera. The correct taking a picture of the ear tag allows to start the process of reading and displaying data from the herd database. The example result, after correct recognition of the cow's ear tag number is shown on Fig. 4.

Source: own work / Źródło: opracowanie własne

Fig. 4. Data about chosen cow seen after correct recognition *of the cow's ear tag numer*
Rys. 4. Dane o wybranej krowie widziane po prawidłowym rozpoznaniu numeru paska identyfikacyjnego krowy

The quality of the markers for launching AR process must be high. It proved difficult to obtain sufficient quality of ear tag photo to use it as a marker. There are a lot of reasons of such situation. The main reasons are: poor light in cowshed, distance to the cow, position of the ear tag (aslant, covered with fur) and its state (dirty, damage). The quality, the parameters of the camera (resolution, screen brightness, matrix size and others) are also important elements. Farmers have, use different mobile devices and rather seldom they take into account the parameters of camera as a priority. To deal with the problem of marker unrecognition we provided the option „Rozpoznawanie ręczne" (manual recognition). It works but it's not Augmented Reality although the data from database are displayed on the background of cow and its environment.

5. Summary

Applications with AR can be useful although they need a new approach of farmers and others involved in agri-food business. AR applications belong to solutions for new generation of farmers.

And as it was said at the beginning, display equipment in AR is very important issue. Smartphones' camera is not the best display equipment, it was the main source of our problems with marker recognition. It generates more complex problem: discouragement from new solutions and new technologies.

6. References

[1] https://en.oxforddictionaries.com/definition/augmented_reality (31.01.2018).
[2] https://www.merriam-webster.com/dictionary/augmented%20reality (28.01.2018).
[3] https://www.gartner.com/technology/about.jsp (28.01.2018).
[4] https://en.wikipedia.org/wiki/Augmented_reality (28.01.2018).
[5] https://www.wired.com/story/ikea-place-ar-kit-augmented-reality/ (28.01.2018).
[6] https://www.republiclab.com/augmented-reality-agriculture/ (28.01.2018).
[7] Nigam A., Kabra K., Doke P.: Augmented Reality in Agriculture. WIMOB '11 Proceedings of the 2011 IEEE 7th International Conference on Wireless and Mobile Computing, Networking and Communications. ISBN: 978-1-4577-2013-0.
[8] Szilagyi R., Herdon M.: Augmented Reality (AR) Applications in Agriculture in the book E-Innovation for Sustainable Development of Rural Resources During Global Economic Crisis, IGI Global, USA, 2014. ISBN: 978-1-4666-4550-9.
[9] https://www.computer.org/portal/web/chasing-pixels-finding-gems/content?g=54397843&type=article&urlTitle=seeing-in-augmented-reality-is-hard (28.01.2018).
[10] Peddie J.: Augmented Reality. Where we will all live, Springer, 2017. ISBN: 978-3319545011.
[11] https://www.ibm.com/developerworks/rational/library/nov05/cernosek/ (28.01.2018).