

# **Big data in agriculture – from FOODIE towards data bio**

Karel Charvát<sup>\*1</sup>, Tomas Reznik<sup>2</sup>, Vojtech Lukas<sup>3</sup>, Sarka Horakova<sup>4</sup>, Karel Charvát Jr.<sup>1</sup>, Michal Kepka<sup>5</sup>, Marek Splichal<sup>1</sup>, Simon Leitgeb<sup>2</sup>, Jan Shanel<sup>2</sup>, Karel Jedlicka<sup>5</sup>, Jaroslav Smejkal<sup>6</sup>

1 Lesprojekt služby

2 Masaryk University

3 Mendel University

4 WirelessInfo

5 University of West Bohemia

6 Zetor company

#### Abstract

What's the role of Big Data in the farming ecosystem? Farmers need to measure and understand the impact of a huge amount and variety of data which drive overall quality and yield of their fields. Among those are local weather data, GPS data, ortophotos, satellite imagery, soil specifics, soil conductivity, seed, fertilizer and crop protectant specifications and many more. Being able to leverage this data for running long and short term simulations in response to "events" like changed weather, market need or other parameters is indispensable for farmers in terms of maximizing their profits. IoT (Internet of Technology) including field sensors and machinery monitoring. The experimentation in FarmTelemetry project demonstrates that one average Czech farm (i.e. around 1'000 hectares) could generate daily 20 MegaBytes of data. This could be only for Czech Republic something between 30 and 50 GB per one day. We may easily reach Terabytes of data a day from agricultural basic monitoring by sensors in Europe. Together with satellite data agriculture will need to manage extremely large amount of data. On one side there is growing whole ecosystem with a strong need to secure Big Data from different repositories and heterogeneous sources. In some cases, sharing of data could be common interest, but on other side, there are also different interests and data could help to one part of value chain to take bigger part of profit. From this reason Big data are sensitive topics and trusting of producers about data security is essential. The producers of seeds and chemicals want to maximize their business with farmers. Our team stated implementation of Big Data technologies in frame of European 7FP project FOODIE. This work currently the work continue as part of DataBio project.

## Background

The agriculture sector is of strategic importance for European society and economy. Due to its complexity, agri-food operators have to manage many different and heterogeneous sources of information. Agriculture requires collection, storage, sharing and analysis of large quantities of spatially and non-spatially referenced data. These data flows currently present a hurdle to uptake of precision agriculture as the multitude of data models, formats, interfaces and reference systems in use result in incompatibilities. In order to plan and make economically and environmentally sound decisions a combination and management of information is needed.

DataBio project is the Data-Driven Bioeconomy, focusing in production of best possible raw materials from agriculture, forestry and fishery/aquaculture for the bioeconomy industry to produce food, energy and biomaterials taking into account also various responsibility and sustainability issues. DataBio project re use and continue on development of FOODIE results DataBio proposes to deploy a state of the art, big data platform "on top of the existing partners" infrastructure and solutions - the Big DATABIO Platform. The work will be continuous cooperation of experts from end user and technology provider companies, from bioeconomy and technology research institutes, and of other partners. In the pilots also associated partners and other stakeholders will be actively involved.



## Methods

The FOODIE project focused on building an open and interoperable agricultural specialized platform hub on the cloud for the management of spatial and non-spatial data relevant for farming production; for discovery of spatial and non-spatial agriculture related data from heterogeneous sources; integration of existing and valuable European open datasets related to agriculture; data publication and data linking of external agriculture data sources contributed by different public and private stakeholders al lowing to provide specific and high-value applications and services for the support in the planning and decision-making processes of different stakeholders groups related to the agricultural and environmental domains.

## The main idea of FOODIE project is to:

build an open and interoperable agricultural specialized platform hub on the cloud for the management of spatial and non-spatial data relevant for farming production discovery of spatial and non-spatial agriculture related data from heterogeneous sources integration of existing and valuable European open datasets related to agriculture data publication and data linking of external agriculture data sources contributed by different public and private stakeholders allowing to

provide specific and high-value applications and services for the support in the planning and decision-making processes of different stakeholders groups related to the agricultural and environmental domains.

which is conceptualized in the following architecture diagram of FOODIE service platform (Figure 2). (Charvat et al. 2014, May), (Charvat et al. 2016, July).

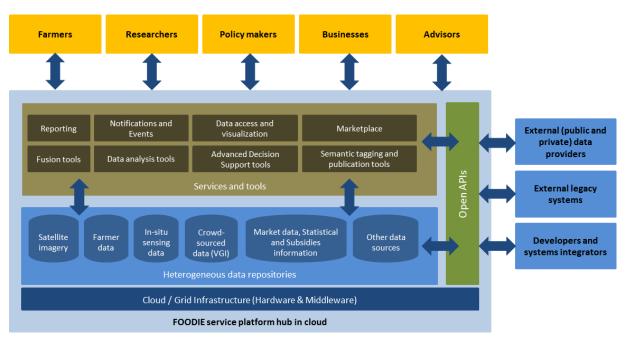


Figure 1. FOODIE service platform hub in cloud

DataBio use reference architecture based on BDVA reference architecture. The reference architecture of DataBio define set of basic modules, which could be implemented using different tools. This reference architecture is on Fig 2.



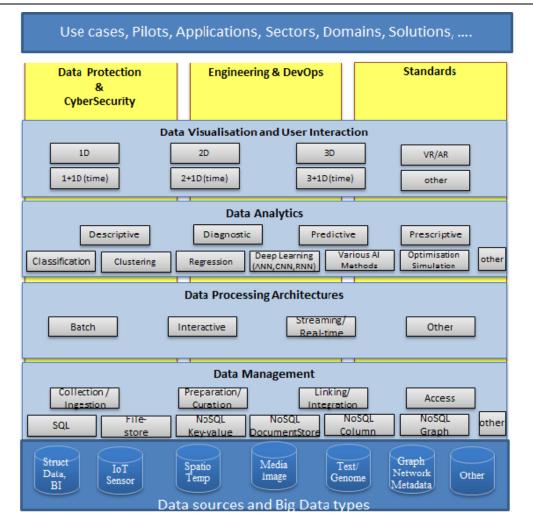


Figure 2. DataBio reference architecture

## **FOODIE Czech Pilots**

The Farm Telemetry system was focused on monitoring of activities and utilization of individual tractors. Data collected by sensor units on tractor allow possibility of analyses and obtaining overall overview for individual farmer's fields (blocks). The field trials during season demonstrate that Farm Telemetry will deal with real Big data. This required optimization on the level of database structures and communication protocols. The main problem is that data from every farm has to be stored minimally for full season, to guarantee complex analysis of costs.



1221014	= + -			17	-Anto-N				
dochines list	Utilization		M	op				inter ad	
Dane al. el. ana	CAS	E 165 M01-0059 M		= = 1 + 1 0	12 8 9		Statistics and statistics		- NB
<ul> <li>COE 44 NOT 0110 MAT 公園区2010 X</li> <li>COE 44 NOT 0110 MAT 公園区2010 X</li> <li>COE 44 NOT 0110 MAT 公園区2010 X</li> <li>COE 1010 NOT 021 MAT NOT 0</li></ul>			aumer Milling	PAT				P R	
ultivated Blocks	Activities log							from the	
CASE 165 M01-0059 MA3 - 2016-05-23	10 10 10	11 10 10	10011100-0010-1	and the	185	- 181	141.111.56	(Annal source)	1-
Time She	11:08627	11:38:15	UUw .	Manue	NA	0.00	00.05.06	UCHRUNCO	1
02-29-17 530-1130/7305/1	11:0215	12:15:02	Other	Stencia	NA	0,00	02:57 < 7	00:57:47	
01:37:20 550-1122/7801/7 00:46:16 530.1150/7004	12:04:02	323922	Other	WEAPA	- 54.8	1.00	00:01:20	00-00-50	1
00.4010 22011207004	12:39:22	1246.22	530 1150/7005/1	W0/102	NA.	1.00	00.07.00	00.00.00	r i
					NA.			00:00:00	1
	12 1/ 12 22	12:12:27	Other	Noves	NA.	2.00	00.00.05		
	12 < 6 22	13:12:27	Criter 520-1130/7004	Mowes Searche	NA.	200	00.02.05	10.07.31	
									P
	12:46:27	13 53 56	530-1130/7004	Seancie	94	0.00	00.97.31	00-07-31	
	17-06-77 12:03:58	13 11 14 12 56 29	530-1130/7004 550-1130/7004 533-1130/7005/1	Granda Works	44 945	0 M 1 00	00.07.31 00.02.31	00:07 31	1
	17-06-77 12:58:58 12:58:28	1551 % 1256 29 1430 60	530-1130/5014 550 1180/5004	Stateste Works Warks	44 94 94	0.00 1.00 0.00	00.07.31 00.02.31 01:32.04	00.00.00 00.00.00 00.00.00	
	17 46 77 12 08 78 12 58 78 12 58 72 14 50 53	125429 125429 143040 141564	536-1130/7004 350 1130/7004 533-1130/7006/1 535-1130/7005/1	Stance Wolks Wates Stance	94 95 94 94	0.00 1.00 0.00 2.00	00.07.31 00.02.31 01.03.04 00.05.01 00.05.19	00.07.31 00.00.00 00:00.10 00:05:01 00:05:01	21
	17.45.77 12.58.58 12.56.28 14.0603 14.25.04	13 13 14 12 37 29 14 30 00 14 15 04 14 40 73	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Stance Wolks Wates Stance	94 95 94 94	5 M 1 00 5 D0 1 M 1 M	00.07.31 00.02.31 01.03.04 00.05.01 00.05.19	00 00 7 31 00 00 00 00 00 00 00 00 00 10 00 00 00 00	21 14
ndyses	17.45.77 12.58.58 12.56.28 14.0603 14.25.04	13 13 14 12 37 29 14 30 00 14 15 04 14 40 73	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Stance Wolks Wates Stance	94 95 94 94	5 M 1 00 5 D0 1 M 1 M	00.07.31 00.02.31 01.03.04 00.05.01 00.05.19	00 00 7 31 00 00 00 00 00 00 00 00 00 10 00 00 00 00	21 14
ndy <del>ses</del> asiso ar andara	12 -05 27 (2.55 28 12 28:25 14 29:52 14 29:52 14 29:52 14 29:52 14 29:52 14 29:52	13 13 14 12 37 29 14 30 00 14 15 04 14 40 73	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Stance Wolks Wates Stance	94 95 94 94	5 00 100 200 200 5 00 5 00 5 00 5 00 5 00	00.07.31 00.02.31 01.03.04 00.05.01 00.05.19	00 00 7 31 00 00 00 00 00 00 00 00 00 10 00 00 00 00	21 14
nolyses 	19 4677 (2018 39) (2018 39	13 13 14 12 37 29 14 30 00 14 15 04 14 40 73	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Segnate Website Website Website Website	94 95 94 94	5 00 100 200 200 200 200 200 200 200 200 2	00.57.31 00.02.33 00.33.54 00.55.04 00.55.04	06-07-31 06-00-00 06-00-10 06-00-10 06-00-00	21 14
ndryses nozo zrandars Year Marka	0 0 07 12 08 07 12 08 02 13 08 02 14 00 03 14 00 14 00 03 14 00 00 14 00 000 14 000000000000000000000000000000000000	13 13 14 12 56 29 14 20 40 14 20 40 14 20 73	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Transie Works Works Stansie Works Haupment	94 95 94 94	500 500 500 500 500 500 500 500	012731 003239 013222 002591 015719 015719	00.00.00 00:00.00 00:00.00 00:00.00 00:00.00 00:00.00 00:00.00 00:00 00	21 14
ndiyses biso ta anzardi Year Manca 2010 3	0 0 6 07 12 56 20 12 56	12 13 14 12 25 29 14 22 90 14 22 90 14 22 90 14 22 73	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Ryupment Byupment Dury 272 7 rod	94 95 94 94	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	01:57:31 00:02:33 01:32:04 00:55:05 00:55:05 00:55:06 000	re-1731 00:00:00 00:00:00 00:00:00 00:00:00 00:00:	21 14
holyses Noo Joannows Year Merits Join 3	0.0 A 27 12.03.32 13.05.23 14.05.04 14.05.04 Frank (2.05.04) Frank (2.05.04) Cost Sale Way 1500 M Cost Sale Way 1500 M	13 12 44 12 56 29 14 25 60 14 25 66 14 42 73 14 42 73	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Equipment But 27/2 7/201	94 95 94 94	5.00 1.00 2.00	012731 00323 003501 005501 015710 015710 015710 015710 015710 015710 015710 015711 015711 015711 015711 015711 015711 0157210000000000000000000000000000000000	no 07 31 00 00 00 00 00 00 00 00 00 00 00 00 00 00	21 14
nclyses hoto promoto- test Manno 2015 2 2015 3 2014 3	0 0 6 07 12 56 20 12 56	13 13 44 12 17 29 14 20 00 14 20 000000000000000000000000000000000	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Sancie Works Warks Sancie Works Hangement Ban 2722 7 rodi podmase according Did	94 95 94 94	5.00 5.00 5.00 7.00 5.01	01 27 31 01 23 34 01 33 24 01 33 24 01 25 14 01 27 31 01 27 31 01 27 31 01 27 31 01 27 31 01 27 31 01 27 34 01 27 34 010	10-07-31 00-00-00 00-00-75 00-00-75 10-00-25 10-	21 14
NG/ yses Nozo 33 d nozors. 2015 - 2 2015 - 3 2014 - 3 2014 - 3	0.0.677 12.0.53 13.0.552 14.0550 14.05000 14.05000 14.05000 14.05000 14.05000 14.05000 14.05	13 13 44 12 24 29 14 25 00 14 14 15 00 14 25 00 14 15 00 14 16 00 16	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Stears Works Works Stears Works Works Have Esurprest DAT 2772 NA	94 95 94 94	0.00 1.00 2.00	00.07.01 00.02.34 00.03.04 00.05.04 00.05.04 00.05.16 00.05.16 00.05.05 00.05 00000000	00.07.31 00.00.05 00.00.55 00.05.51 00.05.55 10.05.55 58 3.3 0 1.5	21 14
nciryses base prightson. 2015 2 2015 2 2015 3 2015 3 2015 3	0.0.0.77 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 10.0.8	15 13 46 12 276 29 14 215 00 14 215	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Specia Work Warks Seeca Ware Hang 272 7 rat Na Na Na Na Na Na Na Na Na Na Na Na Na	94 95 94 94	5 00 5 00 2 00 5 0 5	00 57 51 00 12 54 00 22 54 00 55 50 00 55 10 00 55 5 10 00 55 5 10 00 55 51 00 51 51 00 55 510000000000	regilan 0:00 0:0	21 14
ndlyses bills ja a nains 2015 - 3 2015 - 3 2015 - 3 2015 - 3	0.057 0.057 0.0582 1.0582	13 13 44 12 27 29 14 25 00 14 25 04 14 27 3 14 37 3 14 37 3 14 37 37 37 37 37 37 37 37 37 37 37 37 37	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Typent Work Warks Typent Ware etc	94 95 94 94	0.00 1.00 2.00	0 0 51 51 00 12 34 00 12 35 00 51 50 00 51 16 00 51 51 00 51 51 0000000000	regilan 0:00 0:0	21 14
nd yses Vear 2015 3 2015 3	0.0.0.77 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 12.0.8 20 10.0.8	13 13 44 12 27 29 14 25 00 14 25 04 14 27 3 14 37 3 14 37 3 14 37 37 37 37 37 37 37 37 37 37 37 37 37	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Specia Work Warks Seeca Ware Hang 272 7 rat Na Na Na Na Na Na Na Na Na Na Na Na Na	94 95 94 94	C 10	00151 001281 001354 001514 00157 00150 00000000	00/07 31 (00:00 30 (00:00 30) (00:00 30 (00:00 30 (00:00 30) (00:00 30 (00:00 30) (00:00 30 (00:00 30) (00:00 30 (00:00 30) (00:00 30 (00:00 30) (00:00	21 14
nolryses 700 yses 2015 9 - 2015 9 2015 9 2016 9 2018 1 2018 9 2018 9 2018 9 2019 9 2	0.05.07 10.05.27 10.05.20 10.05.02 10.05.0	15 13 44 12 57 20 14 2500 14 2500 14 25 34 14 25 34 14 25 34 14 25 35 14 25 35 15 35	536-1130/504 250 1130/504 535-1130/7056/1 535-1130/7005/1 535-1130/7005/1 530-1130/7005/1	Type on Weater Weater Weater Weater Weater Kall 2022 21 coll No No No No No No No No No No No No No	94 95 94 94	C 10	00151 001281 001354 001514 00157 00150 00000000	regilan 0, 07 31 0, 00 3 02 0, 00 30 0, 00 51 1, 00 55 1, 00	21 14

#### Figure 3. FOODIE farm telemetry

Yield potential zones are areas with the same yield level within the fields. Yield is the integrator of landscape and climatic variability and therefore provide useful information for identifying management zones (Kleinjan, Clay, Carlson, & Clay, 2007). This presents a basic delineation of management zones for site specific crop management, which is usually based on yield maps over the past few years. Similar to the evaluation of yield variation from multiple yield data described by Blackmore et al. (Blackmore, Godwin, & Fountas, 2003), the aim is to identify high yielding (above the mean) and low yielding areas related as the percentage to the mean value of the field. Also the inter-year spatial variance of yield data is important for agronomists to distinguish between areas with stable or unstable yields. The presence of complete series of yield maps for all fields is rare, thus remote sensed data are analysed to determine in field variability of crops thru vegetation indices.

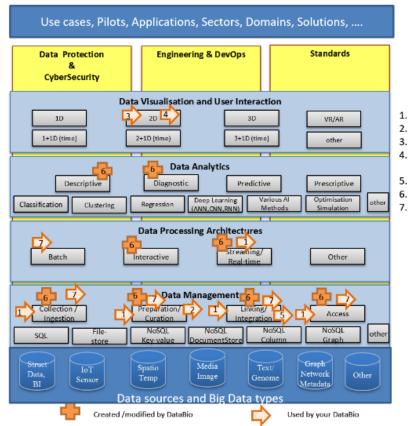


Figure 4. Fertilizer planning application based on yield potential zones



#### Czech DataBio pilot machinery management

Machinery management is focused mainly on collecting telemetry data from machinery and analysing them in relation with other farm data. The main challenge is access to data and data integration, when farmer uses tractors and equipment from various manufacturers with different telematics solutions and different data ownership/sharing policy. In many cases farms or agriculture service organizations owns tractors of more than one brand/family. Although the communication protocols used in control units of farm machinery and data collection are subject of standardization, the telematics solutions including data ownership/usage policy are usually specific to each tractor brand/family and the level. Furthermore, attention shall be paid to ISO and CEN standards regulating data sharing in agriculture basing on the input coming from industry organizations like CEMA and AEF. Although this is not issue and can be even desirable for purposes of tractor producer's customer care responsible for solving technical problems on tractor, for farmers it can be hard or impossible to connect the data coming from tractor with other farm data relevant for agronomical / economical evaluation of machinery usage. Despite the fact tractor have telematics solution, farmer sometimes need to use third party device and software to obtain data for field specific analysis. Zetor Company is currently developing and testing modular telematics solution which is supposed to be part of all Zetor tractors. The solution will provides several levels of functionality ranging from basic telematics for customer care and basic location information for customer to field specific economic analysis and precision agriculture. The highest level of modular solution will offer connection to other data relevant for farm management like field boundaries obtained Land Parcel Information system (LPIS), elevation model and possibly yield potential maps derived from EO data. This connection will enable evaluation of economic efficiency and other analysis on the level of individual fields or even parts of the field. Expected utilisation of DataBio tools is on Fig 5.



- SensLog
- Micka
- HsLayersNG HSLayers-NG Cordova mobile
- application
- Data Model for (Precision) Agriculture
- Farm Telemetry
- EO data processing pipeline

#### Figure 5. Machinery management architecture



## Czech pilot cereals and biomass

The pilot aims to develop a platform for mapping of crop vigor status by using EO data (Landsat, Sentinel) as the support tool for variable rate application (VRA) of fertilizers and crop protection. This includes identification of crop status, mapping of spatial variability and delineation of management zones. The main focus of the pilot will be on the monitoring of cereal fields by high resolution satellite imaging data (Landsat 8, Sentinel 2) and delineation of management zones within the fields for variable rate application of fertilizers. The main innovation is to offer a solution in form of web GIS portal for farmers, where users could monitor their fields from EO data based on the specified time period, select cloudless scenes and use them for further analysis. This analysis includes unsupervised classification for defined number of classes as identification of main zones and generating prescription maps for variable rate application of fertilizers or crop protection products based on the mean doses defined by farmers in web GIS interface. The used tools from DataBio reference architecture are on Fig 6.

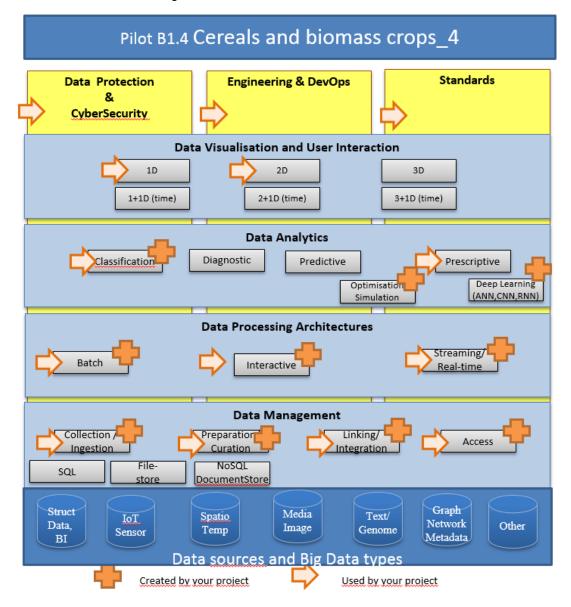


Figure 6. Cereal and biomass pilot architecture



#### **Selected components**

SensLog - SensLog is web-based sensor data management tool. Observations produced by external devices are processed by SensLog. SensLog is focused both on static monitoring devices and mobile devices with live tracking ability.

MIcKA is complex platform comprises a Web Catalogue Service as well as a metadata editor and manager provides the integrated solution required to publish and access digital catalogues of metadata for geospatial data, services, and related resource information. As such it enables to search for as well as maintain descriptions (metadata) on datasets, dataset series, Web services, etc. according to ISO/OGC/W3C standardization documents including Semantic Web principles.

Hlayers NG is a web mapping library written in JavaScript. It extends OpenLayers 4 functionality and takes basic ideas from the previous HSlayers library, but uses modern JS frameworks instead of ExtSJS 3 at the frontend and provides better adaptability.

HSLayers-NG Cordova mobile application - support of mobile platforms is important feature of HSL-NG development. Desktop HSL have responsive design but we are also working on special mobile application using Apache Cordova framework. Current version brings big part of HSL functionality (e.g. compositions, layer manager, search).

WebGLayer is a JavaScript library focused on fast interactive visualization of big multidimensional spatial data through linked views. The library is based on WebGL and uses GPU for fast rendering and filtering. Using commodity hardware the library can visualize hundreds of thousands of features with several attributes through heatmap, point symbol map. Users thus benefit from immediate and dynamic data visualizations, gain better understanding of data by applying filters, and develop the opportunity to discover relationships and patterns in the data.

## Conclusion

Experience and tools from FOODIE are now used in DataBio in building generic Big Data platform for agriculture.

## Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 732064 called "Data-Driven Bioeconomy" (DataBio), the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement No. 621074 titled "Farm-Oriented Open Data in Europe" (FOODIE)

## References

Blackmore S, Godwin RJ, Fountas S 2003. The analysis of spatial and temporal trends in yield map data over six years. Biosystems Engineering.

Charvat K, Esbri MA, Mayer W, Campos A, Palma R, Krivanek Z 2014. FOODIE - Open data for agriculture. Ist Africa Conference Proceedings. 1–9 pp.

Charvat K, Horakova S, Wolfert S, Holster H, Schmid O, Pesonen L, Mildorf T 2012. Common basis for policy making for introduction of innovative approaches on data exchange agri-food industry. Final Strategic Research Agenda (SRA).

Kleinjan J, Clay DE, Carlson CG, Clay SA 2007. Productivity zones from multiple years of yield monitor data. *In*: Pierce FJ, Clay DC. GIS applications in agriculture.

Oerke EC, Gerhards R, Menz G, Herbert GW 2010. Precision crop protection - the challenge and use of heterogeneity. DOI: 10.1007/978-90-481-9277-9.

Řezník T, Lukas V, Charvát K, Charvát KJ, Horáková Š, Kepka M 2016. FOODIE data Model for precision agriculture. 13<sup>th</sup> International Conference on Precision Agriculture. 31 July – 4 August, St Louis, Missouri, USA.

Charvát K, Řezník V. Lukas V, Charvát K. Jr, Horáková S, Kepka M, Šplíchal M 2016. Quo Vadis precision farming. 13<sup>th</sup> International Conference on Precision Agriculture, July 31 – August 4, 2016, St. Louis, Missouri, USA.