Designing a Smart Farming Platform for Sustainable Decision Making

Abstract. Smart farming platforms (SFP's) for pig livestock farming are of increasingly relevance to increase sustainable decision making and enhancement of animal welfare. SFPs involve the whole supply chain and integrate various types of data measured, thus enable data-driven solutions using artificial intelligence. While there exists research about SFPs, issues concerning data governance of SFPs are still lacking. Against this backdrop, we develop a SFP for sustainable decision making with respect to data privacy and data security. Our SFP integrates 4 sensor data sources (e.g., temperature control system, and feeding stations), considers farmer characteristics (e.g., projects with pigs), and provides data-driven solutions (e.g., prediction of animal welfare indicators). We report on the current process situation in pig livestock farming as well as on our concept of SFPs for sustainable decision making. We also report on the evaluation of our SFP by validation against defined requirements during the deployment phase.

Keywords: Smart Farming Platform, Livestock farming, Sustainable decision making, Animal welfare, Data Analytics

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1 Introduction

Sustainable digitalization is rapidly gaining importance in pig farming due to requirements for efficient usage of resources and animal welfare monitoring. Animal welfare monitoring is part of the strategy of the German government to improve animal welfare without losing competitiveness [1]. However, animal welfare monitoring is still in its infancies and current solutions are based on manual data collections, which are sometimes evaluated only twice a year and increase production costs due to increased manual labor [2, 3].

Research on animal welfare often use sensor data (e.g., video camera or microphones) paired with data processing for monitoring and forecast solutions [4–6]. Because animal welfare is often animal-specific, these approaches capture and process animal-specific data [7]. Therefore, Manteuffel and Schön propose a stress level monitoring system using animal sounds [8]. In contrast, Matthews et al. demonstrate a system to detect behavioral changes in pigs using depth video cameras [9]. Also, equipment in bays e.g., feeding or drinking stations produces data to monitor animal behavior [6]. Necessary sensors are already integrated into the housing environment, e.g., feeding and drinking systems or scales. However, especially in pig farming, these individual systems are not interlinked and data is neither stored nor analyzed. This is often caused by economical limitations or technical aspects (e.g., appropriate interfaces to access data). Thus, there is a large potential and responsibility for business informatics to aid farmers with a practical data platform.

While animal welfare and economic aspects are often considered to be incompatible, both issues can work together positively, e.g., prevention of diseases or deaths [10]. Merging already existing data of farms, including sensor data, with data of the whole supply chain in data platforms enable overall data analysis and data processing [11].

Smart farming platforms (SFP's) can be considered as data platform with specific focus on sensor based data collection and machine learning based supportive functions.

As a result, these SFPs can provide functions to support decision making or to control machines [12–14].

While there already exists research about SFP's for livestock farming, specific solutions concerning data security and data privacy still lacking. Previous research focused on independent supportive solutions. To monitor outdoor activities and to detect behavioral anomalies in cows, Taneja et al. propose an SFP for cow livestock farming using interconnected pedometers. [15]. Also, Zhang et al. consider cows and use attached sensors to cows and environment information to monitor activity of livestock's (e.g., grazing) [16]. Ryu et al. demonstrate a concept for a SFP using connected soil, air, and light sensors to enable mobile control of farm devices (e.g., fans, or sprinklers) [17]. Banhazi and Tscharke present a system to automatically measure the live weight of pigs using image analysis without further data use [18]. In contrast, Banhazi demonstrates a system with standalone sensors to monitor air quality in stables automatically [19]. Also, Berckmans proposes a system to detect

anomalies in the environment of broiler houses (e.g., feeding system failures or light problems) [13]. However, these systems do not constitute a SFP, but can be a sub-part of an SFP in terms of integrated data and provided functions. Rodriguez et al. propose an open-source cloud data platform for crops, enable decision support for weed control and traceability of growing processes [20]. Huang et al. show an SFP to analyze supply and demand to support online sales and delivery of livestock products into supermarkets [21]. Additionally, they considered data security, such that users combine a USB-key with standard login to access their data and supportive functions [21].

However, in our understanding, SFP's integrate process related data as well as sensory data to create an inter-company data platform and corresponding data-driven solutions to enhance decision making. We address the following research question:

How to design an SFP concerning data governance for sustainable decision

making?

Sustainable decision making refers to the decision making process, including definition of objectives and criteria's, identifying consequences, and evaluation of alternatives [22]. A decision is sustainable if the decision targets economic as well as ecological objectives [23]. This paper has been divided into five parts. The first part define requirements for an SFP using interviews with experts. The second section describes our design of an SFP, split in data integration and data-driven solutions. Subsequently, we report on our evaluation of the artifact using a real world deployment and expert assessment. The final sections gives a brief discussion and conclusion.

2 **Problem specification**

This chapter investigates the current situation at the Boxberg Teaching and Research Centre to identify problems and to deduce requirements for an SFP. The Boxberg Teaching and Research Centre – Centre for pig rearing and pig breeding (LSZ) is a subunit of the Ministry of Rural Affairs and Consumer Protection of the federal state of Baden Württemberg in Germany. The facility provides places for at least 250 sows, 3.500 piglets in multiple buildings, consisting of conventional (air-conditioned stables), and alternative (no air-conditioned stables) design and an internal slaughterhouse.

The facility hosts various research projects and provides pens with sensors to collect necessary research data. This includes unique data records of 30 video cameras and numerous pens with RFID hot spot monitoring collected in federal funded research projects. These projects study animal welfare as well as managerial aspects of pig farming with a practical orientation (e.g., effect of bay equipment on animal welfare).

In our study, we analyze the status quo of work processes, data management, stakeholders as well as information systems. Therefore, we interviewed experts (experimental technicians, senior officials, research project managers and operational employees working in the barn of the institute) in individual interviews and group

interviews. These experts work in different work areas, from staff in stables, via area managers to staff in projects (projects in pig stables). Hence, they provide very detailed insights as well as intercompany aspects.

2.1 Data Management

Data management is conducted by experimental technicians at the LSZ. These experimental technicians integrate manually recorded routine research data (e.g., medication, breeding data, and pig location) and information system data (e.g., feeding and slaughterhouse data) into an unnormalized Excel file. The most accessed file stores all available routine research data for each pig and contains records for the last 12 years (over 50,000 rows and 90 columns). Slaughter data (more than 30 variables per animal) is extracted from a slaughtering system as a .csv file and appropriately integrated into the 90 columns. Furthermore, project-specific experimental technicians integrate sensor data for each project individually (e.g., temperature sensor, RFID hotspot data or video cameras). However, because sensor data is stored in decentral databases, the experimental technicians transfer data from these sources manually into heterogeneous stand-alone Excel files or Microsoft Access) as shown in figure 1. This results in various not integrated and not harmonized data pools as well as redundant data. Also, data pools are not well structured and may not be compatible, due to different data formats and data meanings. Similar analyses on these data sources may lead to different results. As a consequence, there exists no single point of truth and merging data leads to expensive manual tasks. Due to these findings, we define the following functional requirement for a SFP:

• Functional requirement 1: The SFP shall integrate data from manual data collection and automated data collection.

Requirement 1 aims to replace stand-alone data pools and integrate sensors using automated processes. As a result, the SFP includes all available, relevant information and provides a single point of truth.



Figure 1: Data management

2.2 Information systems

Currently, there exists at least 20 information systems as stand-alone solutions supporting the facility's work processes. These solutions ranging from Microsoft-

Excel based applications to more advanced planning applications for sows (e.g., sow planner). Each stand-alone solution provides its own data management, interfaces, export formats, and export possibilities. As a result, these information systems are incompatible, resulting in redundant data processing, less automated interfaces, various manual processes, and handwritten data. In addition, an overall data preparation, and data analysis (e.g., using machine learning methods) are not possible yet. Due to these findings, we define the following functional requirement for a SFP:

• Functional requirement 2: The SFP shall provide application independent interfaces for data import and data export.

Requirement 2 aims to remove incompatible interfaces for not substitutable information systems and provide the automated use of interfaces. Data export functions should support easy and quick data analysis. Interfaces for data import aims to provide a more efficient way for manual processes towards a fully automated system.

2.3 Business processes

The core rearing process starts with artificial inseminations of the mother, followed by a pregnancy and birth of piglets. Piglets remain by her mother at least 21 days and get reared in different groups and bays based on their growth. The pigs get slaughtered at a weight of around 120 kilograms. Due to a state analysis, primary and secondary business processes were identified and assigned to process owners, as shown in figure 2. These business processes often consist of manual tasks, like reading weights of a scale, or animal welfare indications and inserting these into Excel-files. However, there is no kind of verification (e.g., maximum and minimum weight thresholds) during manual data entries. Furthermore, Excel-files define the manual starting point to build reports. Excel-files are stored and shared in network drives, accessible via stationary workstations using a LAN-connection. Other aspects are projects and statistical data analyses. Projects and analyses can influence or causes changes in process parameters like the stable design or feeding plans. These processes require coordination among different process owners, mainly consisting of recorded data or information. Due to these aspects, we define the following additional functional requirement for a SFP:

• Functional requirement 3: The SFP shall provide interfaces for real-time queries and data analytics.

Requirements 3 aims to provide plausibility checks (e.g., a weight later in time can only be inserted after weights earlier in time), and real-time information (e.g., the number of pigs in bay, or the average weight within one week of already rehoused pigs). Therefore, requirement 3 should support staff in various situations. Furthermore, this requirement should replace and enhance the creation of already existing reports. It enables working with mobile devices, resulting in more flexible processes.

2.4 Stakeholders

The research facility is organized into multiple divisions (e.g., building with conventional stables, or slaughterhouse) and hierarchical levels (e.g., division manager, experimental technicians, livestock farmers, and statisticians). Therefore, governance concerning the responsibilities and powers of these different stakeholders already exists. This includes for example rules about read and write access to various aspects (e.g., process-related Excel-files). Each workstation is embedded in a secured intranet and access data in a separated internal location.

Due to these aspects, we define the following additional functional requirement for a SFP:

• Functional requirement 4: The SFP shall provide suitable technics to prevent prohibited data access and use of the smart data platform.

Requirement 4 aims to prevent data theft and data duplication, supply transparency and historicisation of data modifications. Furthermore, requirement 4 enables the recovery of data as well as the enhancement of security and privacy mechanisms, detected at a later time.



Figure 2: Business processes

3 Design

This chapter depicts the design of our SFP constructed against defined requirements. Figure 3 shows the overall architecture of our SFP, including components for external data (*ETL*), user interfaces (*Web*) and a data warehouse (*Data Warehouse*). This architecture, especially the *ETL* and *Data Warehouse*, is based on a Hub and Spoke architecture (e.g., described by Ariyachandra and Watson [24]), whereby the functionality to meet requirements is shaped in the different components. The *ETL* component extracts data from heterogeneous machines or systems (e.g., temperature control, video cameras, slaughters or feed troughs) and inserts integrated data in a data warehouse. In contrast, the *Web* component manages user, rights, manages stored data, and provides data analytic functions as well as reporting functions. Therefore, our *Management* component (see figure. 4) mainly consists of three sub-components – a data analytic component (data analytic) for forecasting or detection

methods (e.g., machine learning), reporting component and data management component. This architecture is designed to run on a single farm with a modular extension of data processing components, data sources, and visualization.







Figure 4: Management Component

3.1 Management component

The *Management* component represents the business process logic, corresponding objects and functions, and process owner structures. Included functions consist of currently manual or automated tasks (e.g., calculate the mean weight in Excel or provide data access to new employees), and new functions using the potential of integrated data in an SFP (e.g., enriched reports, use of temperature data for statistics, or location independent data management). Therefore, the *Management* component consists of specialized components to address different use cases:

- Data analytic: Provides models and functions to predict animal welfare indicators or detect pig behavior in real-time.
- Reporting: Creates reports and views for different user groups.
- Data Management: Manages user, privacy, manual inputs and master data.

Each *Web* component does not store data to enable data visualization (e.g., dashboards), data export or data import, thus the *Management* component provides interfaces to receive data via RESTful-APIs. We use a central REST-API component for system access, to encapsulate underlying components as well as to enable a central user authorization and data privacy management. The REST-API component calls functions in other components and returns the merged answers. In addition, these

component records each request, including request data, to support historicization and transparency. Furthermore, these loosely coupled components enable modular extensions as well as function sharing between components. This component has been created to comply with requirement 2 concerning user interfaces for data import and data export.

Data analytic

The *Data analytic* component aims to provide computation-intensive functions, like forecasting, and user-designed functions. Users can insert own calculations on underlying data as well as import results from an external application using excelfiles. Computation-intensive functions consist of trained machine learning models or trained neuronal network models, thus we can replace these models repetitively by using more data of the data warehouse. While machine learning algorithms predict animal welfare indications, especially the mortality during the lactation period, neuronal networks recognize the behavior and location of pigs in bays by using video cameras. Dashboards may use these functions for real-time monitoring. Likewise, these functions can supervise a longer period, thus enrich reports. Furthermore, analytic methods for additional issues, especially analyze lying positions. To sum up, the *Data analytic* component is regarded to requirement 3.

Reporting

Institute employees use operational indications (e.g., the number of slaughtering or the average mast weight) and animal indications (e.g., the birthrate of pigs or the number of injuries) for controlling or planning across the institute. Accordingly, the *Report* component creates appropriate reports as PDF and .csv-file, or excel file for further analysis. Especially, this component provides reports for the different breed phases (breastfeed, rearing and mast) and holding register. These reports exist in different kinds of data granularity, e.g., daily, weekly and monthly. Besides export possibilities, other components or user interfaces can consume and visualize these data for further application. Therefore, this component mainly considers requirement 2.

Data management

Unless all new data is measured and processed automatically, employees have to collect data and transmit these data into the platform via user interfaces. Therefore, the Data management component validates and processes submitted data to the SFP. Moreover, this component provides access to stored data and basic platform functions (e.g., user management, data privacy management, or core data-management). Users can activate and deactivate core data, resulting in an extra column of corresponding data tables to prevent deletion. Another aspect is the provision of validation functions and shared functions. Shared functions define functions, that can be useful for other components and functions (e.g., get current bay and position of pig x). As a result, each method is implemented once. Validation functions. This component uses the data mart of the data warehouse to provide real-time information, accessible via REST-APIs (e.g., show past throws of sows). Changing data privacy rules affect other components (e.g., *Data Analytic*) and available functions. Therefore, this component has been created to comply with requirement 4 concerning data access.

3.2 Data Warehouse

The data warehouse stores various kinds of data, as shown in figure 5. This includes data about pigs, the environment of pigs as well as projects and operational data. While pig's data consist of weights, states of health, treatments, or family background, environmental data contains food data, equipment of bays, or temperatures of bays. The Extract, Transform and Load Processes (ETL) components insert environmental data of heterogenous sources using ETL-processes. Furthermore, project data connect projects with for example pigs, environmental data or states of health to enable the comparison of projects or identify effects. Operational data include basic data for user management or rights management as well as slaughter data, suppliers or customers. Each data source is stored in a different database schema, resulting in a modular and expandable data structure. A data mart complements the data warehouse to increase performance for repetitive or timeconsuming queries, by using precalculated views. These views get updated at regular intervals to consider new and updated entries. To prevent performance impairments during working hours, the SFP updates most of the views at night. The Data Warehouse component is regarded to requirement 1.



Figure 5: Database schema

3.3 Extract, Transform and Load Processes

Machines (e.g. temperature control in bays or feeding control) or systems for specific tasks (e.g. slaughtering, planning) produce different kinds of data. The *ETL* component aims to extract data of legacy systems or files, and productive systems or machines. Therefore, this component supports multiple communication and connection standards, e.g., SOAP, HTTPS or SQL. Each data source uses its own process to extract, transform and load data into the data warehouse. This process checks at regular intervals if new data is available and extract it. Besides standard data transformation and insertion, data is linked automatically to other data of other tables or systems, if there exist mapping rules. Mapping rules include predefined mapping tables with similar mapping keys as well as automatic detection of similar table columns and primary keys. In other words, newly inserted data can be used by other components instantly. In contrast, the user has to create new mapping rules. This requirement has been created to comply with requirement 1.



Figure 6: Web component

3.4 Web

Figure 6 shows the *Web* component, mainly consists of three sub-components, a dashboard component, administration component, and data integration component. The dashboard component displays relevant information and provides real-time monitoring solutions using video cameras and neuronal networks. Displayed information is individualized by user responsibilities and groups. Furthermore, this component provides reports and views of the included data mart. In contrast, the administration component enables access to single database records and consists of user interfaces to change rights, users and core data. Users can insert process data manually via input masks of the data integration component. Input masks for different process phases (e.g., rehousing form breastfeed phase to rearing phase) use inserted data to show relevant information (e.g., number of pigs in the bay), thus support the user. This component is regarded to requirement 2 and 3 concerning the user interface for import and export possibilities.



Figure 7: Security concept

3.5 Data Security

Our smart farming platform manages sensitive and confidential data. Therefore, security and in particular data access is essential. With regard to security requirements, we introduce different networks, restricted data warehouse access and rights management for users. Figure 7 shows our network with restricted access. While the data warehouse runs in a secure intranet, the *Management* component runs in different intranet without internet access and closed ports except the data warehouse port and ports to access machines and sensors. Users of secured workstations connected via LAN to the secure intranet can use the smart farming platform too. To access our system with mobile devices (e.g., tablets or smartphones) we use an encrypted wireless network without access whether to the intranet, internet or anything except the *Management* component. Machines and sensors in stables are interconnected using an additional LAN network similar to the wireless network, especially for stables. Besides these different network layers, basic authentication or

token authentication is required to access the system, to enhance safety. If no valid token or basic authentication is included, the SFP refuses the request. However, an active directory account can provide access from the secure intranet too. Furthermore, this component has been created to comply with requirement 4 concerning unauthorized data access.



Figure 8: Data Privacy

3.6 Data Privacy

Besides prohibited access to data, data privacy for SFP users is another relevant aspect. We integrate the right management for each visualization of data (e.g., dashboard and export possibilities) as well as for manual data input. The right management for manual data affects input masks and real-time information for inserted data in input masks. Therefore, we create rights for each mask, dashboard, and core data entry (e.g., bay, building or supplier). In this case, reports are a specialization of dashboards. Administrators can assign these rights to users or user groups (see figure 8), thus enable restricted data access. Each API-Request get validated against assigned user groups, thus if no required group is included, the *Data Management* component returns a not authorized response status. Changing data privacy rules affect all other components (e.g., *Data Analytic*) and their available functions. Also, this component is regarded to requirement 4 concerning authorized data access.

4 Evaluation

This chapter describes the evaluation of our artifact by validating the 4 defined functional requirements. This validation depends on the assessment and test of the experts, whether our artifact can be used as a productive system or not. Using our artifact as a productive system instead of current solutions corresponds to the full compliance of the defined requirements. Therefore, we introduced our artifact and stakeholders execute old work processes (e.g., using paper and Excel-files) as well as new work processes (using our artifact) simultaneously. Subsequently, they can compare results (e.g., reports, or data records) of both work processes.

We implemented our artifact using Django 2.02 based on Python 3.5 (*Data Management* component, and *ETL* component), PostgreSQL 9.5 (*Data Warehouse* component), and React 16.8.6 (*Web* component). While the *Data Warehouse* components run on a Windows-based server, the *Data Management* component and *Web* component is served on a Linux based server. The Networking of each component is realized according to figure 6.

The Web component consists of at least 20 input masks for routine data, supported by real-time information (e.g., the average weight for a selected bay, or current anomalies for each piglet), and more than 10 input masks for master data. Each mask is accessible from browsers, thus enable location independent work. Therefore, each building with stables is equipped with WLAN and mobile devices, consisting of larger smartphones. Besides the integration of historical data from current data files (e.g., Excel-files), we integrated temperature data of bays, movements of pigs, slaughter data, feeding data, health data of pigs, and data from pig RFID transponders, using the ETL component. RFID transponder are used to monitor behavior of pigs in areas equipped with activity elements. Different processes integrate new data of these sources, in intervals of five minutes to limit required computing resources. Due to handmade inserts in current data files, a manual data preparation was necessary, otherwise for example names of breeds induced visualization errors. Data from input masks (in the Web component) and the ETL component is inserted into more than 100 database tables in multiple database schemas. Each stakeholder is registered and assigned to multiple user rights to represent the responsibilities and powers of the divisions and hierarchies.

During the first simultaneous use of our artifact and the previous solution, stakeholders provided first feedback. This included software bugs as well as missing supportive functions or incomplete supportive functions. For example, input masks did not contain enough real-time information or additional input fields. Subsequently, we remedied or improved these aspects and restarted our artifact again. We conduct this approach currently to enable fully evaluation by the experts.

First impressions provided by stakeholders indicate more efficient and simplified work processes (especially the insertion of weight data, sharing data and further processing of data in individual applications). In addition, sensor data can enrich individual analytics and reports are more transparent (compared to the old solution).

5 Discussion

We contribute a SFP to enhance sustainable decision making as well as animal welfare. Therefore, we integrated various types of data related to the complete breeding process as well as environmental sensor data (e.g., the temperature in bays, movement behavior in stables, or amount of food). Subsequently, data analytic methods support stakeholder's decision making.

We evaluated and implemented our artifact in a larger pig research farm by validating defined requirements. This evaluation is based on the expert's assessment. As a consequence, there exist no measurements of data analytic methods and decision support functions usefulness. Furthermore, stakeholder's acceptance (includes e.g., the consideration of the usability) was not considered. However, acceptance is a relevant criterion for employees and can be addressed in future work.

Also, defined requirements are justified by these experts and implemented in consideration of local circumstances (e.g., data files, organizational structures). This may lead to a complicated transferability to other research institutes or farms.

From the practical perspective of the business processes, our artifact can simplify and renew processes. Due to providing web-based access to our artifact, employees can work location-independent (e.g., at the office or the stable) and view the same data. Employees can use any device with network access and installed browsers (e.g., smartphones or tablets). Thus no special equipment is required. As a side effect, the farm or research institute will be equipped with required technical infrastructure (e.g., router in stables to provide a comprehensive wireless network or tablets instead of desktop computers or notepads). Also, this infrastructure can be used for further projects. Using a central SFP with plausibility checks reduces the potential for manual errors and data defects. Thus, time to correct data or to insert missing data is reduced. Integrated data of different sources and processes provide the basis for additional data analysis and corresponding predictive functions (e.g., predict diseases, pig's growth rate, or detect anomalies). Hence, farmers can access easily these data analysis potential to improve their processes and animal welfare further, without required technological and mathematical knowledge.

During the problem specification, we discovered some organizational challenges, especially concerning insufficient process documentation, complex identification of pigs, and iterative artifact deployment. Process documentation and analysis provide a better understanding of process tasks and dependencies, resulting in comparable SFP processes (e.g., weigh the pig and capture his welfare during the rearing, repeat this procedure in the mast phase and decide when the pig is ready to be slaughtered). The identification of pigs depends on the rearing phase and multiple keys (some can be reused for another pig), resulting in mapping function between key structures in the real process situation. Therefore, captured data (e.g., weights) are inserted into the SFP and legacy Excel-files during the deployment, resulting in increased workload and potentially inconsistent data. This is resolved by importing existing Excel-files into the SFP and provide export possibilities to use well-known applications (e.g., Excel).

At a very abstract level, our SFP can be used for other livestock farms, like cows, or chickens. However, on a more detailed level, the processes and corresponding SFP elements, like data structure, data analytic functions, and reports, differ significantly.

Another aspect affects integrated and available data. While process-related data and sensor data are integrated, the SFP does not contain economic data, like personnel funds, the temperature of administration buildings, or overhead costs. However, the price for feed (changes weekly), or slaughter redemption prices (changes frequently) are included to provide price developments. Integrated data (e.g., temperature sensors) requires an individual integration process. Therefore, multiple onetime and manual tasks are necessary to integrate new data sources. We also integrated projectrelated data (e.g., equipment of stables, or feeding forms), that may not be relevant for farms or differ from procedures in other research institutes. Further research is necessary to use the complete database to build specialized decision-making functions as well as to create functions to enhance animal welfare (e.g., predict animal welfare indicators). While we focused our artifact on data security and data privacy, we cannot provide detailed insights (except the conception) to preserve company secrets. Besides our aim to integrate heterogeneous data sources for decision support, we did not focus on a self-adjusting system (e.g., for climate or feeding control, or rehousing of pigs). However, our artifact can constitute a basis for self-adjusting systems in the future. Furthermore, we report the design of a SFP, than can be adapted by farmers to meet own circumstances. Farmers can easily integrate own data analytic methods or export data to use current solutions. Also, they can integrate more sensors and monitoring solutions.

6 Conclusion

We proposed a smart farming platform (SFP) for sustainable decision making in pig livestock farming. Our SFP integrates heterogeneous data sources (e.g., slaughter data, feeding data, temperature sensors, or animal welfare sensors), consists of supportive functions for work processes (e.g., real-time information) as well as decision support functions for visualizations and reports. We defined requirements for an SFP based on interviews with experts of a larger pig research institute with an attached farm area. Subsequently, we developed a SFP meeting these requirements and implemented the SFP in this research institute. Experts started the evaluation of our artifact. Currently, we consider feedback of these experts and improve the artifact to comply in full with defined requirements First evaluation impressions indicate simplified and more efficient work processes. As a result, the SFP has the potential to replace past solutions of not integrated information systems and data sources. We inspect changes in work processes and acceptance by users further. Also, we will in our future research address additional data analytic methods using integrated data to enhance animal welfare. The enhancement of animal welfare as well as the understanding of correlations between sensor data and animal welfare is an ongoing research task.

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