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Deliverable D3.1

For the SusAn project:

Improving pig system performance through a whole system approach

PigSys

Report on data integration

An integrated goal throughout the PigSys project is to develop a decision support system (DSS) which can provide the farmer with relevant data-based information in real-time. By using a DSS the farmer can make decisions in the everyday management of the herd which are based on more information than can be obtained during the daily check of the animals. Hereby the farmer can aim first focus on the specific tasks which need primary attention as opposed to attending each task one by one in a constant routine. Tasks which need primary focus can be concerning both direct animal management (treating sick animals or conducting preventive interventions to avoid outbreaks of diseases) or crucial parts of the production site such as errors in the climate control, feeding system, or water supply.
The overall concept of sensor-based detection models is to automatically detect a given condition based on continuous real-time monitoring by one or more sensor (Dominiak *et al.* 2019). This real-time monitoring can also be integrated in environment control through advances in precision livestock farming (Fournel *et al.* 2017). Historic data can, however, provide important additional information on the specific herd.

ThermiPig model
In the PigSys project, a multi-object mechanistic, dynamic and deterministic model, called ThermiPig, was developed to allow for the prediction of the within-room thermal balance at the room scale under different climates. The model was written in Python language. A growth model (InraPorc) and a bioclimatic model (Thermisim) were combined with a common 1-hour time-step. Different characteristics of the rooms (insulation, equipment and regulation rules), management, type of pigs and feeding conditions are considered and their impact on the multicriteria performance of the batch of pigs in terms of (i) growth performance, (ii) energy use, (iii) nitrogen output, (iv) margin on feed and electricity cost are simulated. Evaluation of the model was based on the comparison of *in silico* indoor hourly temperatures (which is the most sensitive variable in bioclimatic models) to values measured during a study carried out in the IFIP demonstration farm. The average difference was less than 0.5°C over the whole fattening period, with *in silico* growth performance being similar to *in vivo* ones (Brossard *et al.* 2019).

ThermiPig model aims to make one simulation per batch of indoor thermal conditions considering optimal welfare and productivity (growth). The model can also be run daily, each time with the data collected on the last day uploaded (real time). A run per day is the minimum step that can be accounted for, even when outdoor and indoor temperature are considered on an hourly basis. This is due to the initial time-step of the growth model that simulates daily performance of pigs, daily heat production included.

Data integration

In ThermiPig model, both historic and real time data are fully integrated. All static inputs are considered as historic data, including building and ventilation characteristics (Fig 1), management practice, room and pig characteristics (Fig 2) as well as feeding conditions and pig performance characteristics (Fig 3). Dynamic inputs (Fig 4) are to some extend considered as historic data as well if the model is used to make simulations of indoor thermal once per growth period, based on the hourly characteristics of the outdoor conditions collected over a period of 3 months (equivalent to the average length of a growth period for a batch of finisher pigs).
Dynamic inputs can, however, be considered as real-time data by ThermiPig as well. This is the case when data are aggregated per 24 hours and uploaded to run the model every day to check if everything was correct on the day before or not. Such dynamic information can be used by the farmer to further optimize parameters as for instance climate control and feeding strategy.

Data interfaces

As described above, extensive amounts of static and dynamic variables have to be used to monitor what happens in fattening rooms. A web user's interface was developed to ease the process of data collection. It is accessible online: https://pigsys.science.itf.llu.lv/. Any interested person can freely log in and test it. Each user can define multiple property sets, copy and delete them. In each fulfilled property set, the user describes his fattening room, chooses its location and the time of the year, the type of pigs and the feeding strategy. Depending on the type of information, the user chooses the inputs in a list of suggested items (type of floor, ceiling, equipment available or not) or fulfil the cells of the tables with figures (e.g., size of a pen, numbers of pigs, power of equipment).

The concept of the data warehouse was applied to provide an API to connect the ThermiPig model (see above), stored in France to the data warehouse hosted in Latvia by LLU. Through the API, the model directly gets the input values from the remote data warehouse on-demand or scheduled according to user's request and computation power is made available for modelling. It consists of following logical steps: authentication of machine-to-machine application (the script) and token acquisition, requesting the system wide list of property sets available for processing, in loop fetching parameters for a given property set, external modelling and sending results back to the data warehouse (Grausa *et al.* 2020).

After the modelling step, outputs of calculations and simulations are transferred directly to the remote data warehouse and available in the user interface. Average performances are presented in a table (average daily gain, feed intake, feed conversion ratio, N output) and dynamic change in outdoor and indoor temperatures are presented in graphs.

Conclusion and perspectives

The developed data warehouse allows currently the storage and the management of data from experiments and farms. These data can be used in ThermiPig model for integration and to help the farmers to optimize their management. Both historic and real-time data are considered.
Next steps for this work are to ease real-time integration of data directly from equipment in the farms and to implement relationships between other DSS and data in the data warehouse. This will offer to stakeholders the possibility to use real-time DSS to manage pigs' herds and to study ways of optimization of their management.

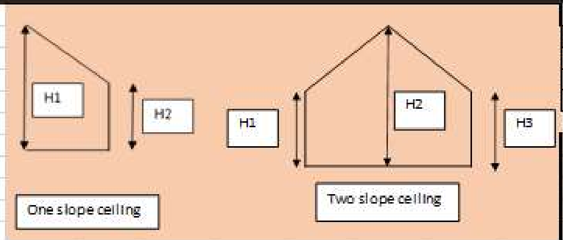
Brossard, L., Cadero, A., Dourmad, J.Y., Renaudeau, D., Garcia-Launay, F., Marcon, M., Quiniou, N. (2019). Combining a bioclimatic and a growth model to assess the effect of management practices and building ambiance on growing pig performances at the batch level. *9. Workshop on Modelling Nutrient Digestion and Utilization in Farm Animals (Modnut)*, Sep 2019, Ubatuba - Itamambuca, Brazil. Advances in Animal Biosciences, 10 (2), 367.

Dominiak, K.N., Pedersen, L.J., Kristensen, A.R. (2019). Spatial modeling of pigs' drinking patterns as an alarm reducing method I. Developing a multivariate dynamic linear model. *Computers and Electronics in Agriculture, 161*, 79-91. Doi: https://doi.org/10.1016/j.compag.2018.06.032

Fournel, S., Rousseau, A.N., Laberge, B. (2017). Rethinking environment control strategy of confined animal housing systems through precision livestock farming. Biosystems Engineering, 155, 96-123.

Grausa, K., Komasilovs, V., Brossard, L., Quiniou, N., Marcon, M., Querne, M., Kviesis, A., Bumanis, N., Zacepins, A. (2020). Usability improvements of the Thermipig model for precision pig farming. *Agronomy Research*, *18 (S2)*, 1300-1306. doi: https://doi.org/10.15159/AR.20.029

GENERAL INFORMATION FOR THERMISIM MODULE			
First day of the simulation		21-10-2019	
Dynamic data or regulation rules			
Use of dynamical inputs for fan regulation		No	Yes = it means that data are fulfilled directly in the sheet "THERMISIM_dynamic_inputs" from sensors (collumns H to M) / otherwise regulation rules have to be described in the present sheet
Use of dynamical inputs for heater regulation		No	Yes = it means that data are fulfilled directly in the sheet "THERMISIM_dynamic_inputs" from sensors (collumns N to R) / otherwise regulation rules have to be described in the present sheet
REGULATION RULES			
Fan system			
Fan_T_setpoint_initial	°C	24	When pigs are entering the room
Fan_T_setpoint_final	°C	22	When pigs are about to leave the room
Fan_T_setpoint_duration	Days	15	Number of days between the T°setpoint Start and End
Fan_T_setpoint_empty	°C	10	When the room is empty
Fan_rate_min	%	10	
Fan_rate_max	%	100	
Fan_T_range	°C	6	Number of °C needed to go from minimum to the maximum ventilation rate
Fan_number		2	Number of fan within the room
Fan_diameter	mm	400	Diameter of the fan in milimeter
Fan_brake	choose in the list	normal	Is the breeder using an hatch to reduce the minimum air flow during winter?
Heating system			
Heating_T_setpoint_initial	°C	28	When pigs are entering the room
Heating_T_setpoint_final	°C	24	When pigs are about to leave the room
Heating_T_setpoint_duration	Days	50	Number of days between the T°setpoint Start and End
Heating_T_setpoint_empty	°C	10	When the room is empty
Heating_rate_min	%	0	
Heating_rate_max	%	100	
Heating_T_range	°C	1	Number of °C needed to go from minimum to the maximum heating rate
Heating_total_power_room	Watt	0	Total accumulated power of heaters in the room
Room description			
Room_width	m	10.41	
Room_length	m	11.61	
Ceiling_type	choose in the list	2-slope Ceiling	
Ceiling_suspended_height	m	2,6	
Ceiling_slope_H1	m		
Ceiling_slope_H2	m		
Ceiling_slope_H3	m	2.6	
Window_number		2	
Window_width	m	1.2	
Window_height	m	0.6	
Air_inlet_type	Ceiling/other	2-slope Ceiling	
Wall			
Wall_thickness_1	m	0.07	Normaly there are one material = concrete and an other = insulation
Wall_T_conductivity_1	W/m/°C	1.7	
Wall_thickness_2	m	0.12	
Wall_T_conductivity_2	W/m/°C	0.036	
Wall_thickness_3	m	0.07	
Wall_T_conductivity_3	W/m/°C	1.7	
Additionnal items			
Heat_exchanger_air_air	None or yes	None	
Heat_exchanger_T_setpoint_starter	°C	25	
Cooling_Type	None or yes	None	
Cooling_T_setpoint_starter	°C	25	
Ventil_economy	None or yes	Yes	
Ventil_Centralised	None or yes	None	
Slatted floor	choose in the list	Fully	



Multichoice
Suspended ceiling
1-slope Ceiling
2-slope Ceiling
Choose

Fig 1: Examples of static inputs of ventilation and building characteristics for the ThermiPig model

Management practices			
Delivery to slaughter house (rules) ==> the way the room is progressively emptied at the end			
Departures1 [dd/mm/yyy, number of pigs] Departures2 [dd/mm/yyy, number of pi		[17/12/2018,53] [03/01/2019,40]	
Number of days between the announcement of the delivery and the depart	day	6	Delay between the call to schedule a shipment and the shipment
Number of days between two deliveries	day	17	Possibility of a delivery every n days
Number of days between sorting session of pigs and delivery	day	6	The farmer selects the pigs n days before the delivery
Minimum number of pigs per delivery	pig	40	
Rate of shipment tolerance		0,05	Allowed flexibility between the announced number of pigs and the effective number at delivery
Minimal live weight for positive carcass paiement	kg	102,6	**example = based on the French carcass paiement system**
Maximal live weight for positive carcass paiement	kg	130,8	**example = based on the French carcass paiement system**
Minimal live weight for maximal carcass paiement	kg	109	**example = based on the French carcass paiement system**
Maximal live weight for maximal carcass paiement	kg	124	**example = based on the French carcass paiement system**
Objectif live weight for shipment to slaughterhouse	kg	115	Minimum live weight at which the farmer wants to deliver individual pig to sluaghter house
Average daily gain estimation used for shipment decision	kg	0,9	Estimation of final ADG assumed by the farmer, in order to estimate the pigs weight at the day of delivery
Feeding strategy			
Feeding rationing plan		Ad libitum	Name of the feeding rationing plan applied
Feeding sequence		PigSys_France_b507	To be choose later in a list based on partners' descriptions in sheets 3 or 4
Level of application of the feeding strategy		room	Choose ROOM for THERMIPIG
Type of feeding rationing plan		Ad libitum (uniform)	Choose Ad libitum (uniform) for THERMIPIG if Ad libitum cell C16
Hours of meal deliveries or main spontaneous intake		[8,11,14,17]	Here 4 meals considered per day - ad libitum = 4 main hours when the feed intake occurs mainly
Batch management			
Number of days between the arrival of two succesive batches in the room	day	119	Fattening duration + disinfection period
Disinfection period (room is empty between 2 batches)	day	5	
Effective number of pigs per batch	pig	96	Used to calculate the pig density in the fattening room (influence on feed intake)
Pig allocation rules to pens		per weight	Pigs are separated into pens randomly or depending on criteria (weight, sex, weight and sex)
Room characteristics			
Theoretical number of places in the room	place	96	number of pigs the room has been designed to contain
Number of pen in the room	pen	16	
Number of theoretical places per pen	place	6	
Surface allocated per place	m²	0,7	
Pig's characteristics			
Mortality rate		0,03125	mortality rate over the whole fattening period
Accounting for inter-individual variation of growth potential		Yes	
File name for animal profile if variability not used		file.rec	File created using InraPorc® based on description in sheets 3 or 4
Animal profile name if variability not used		file.rec	File created using InraPorc® based on description in sheets 3 or 4
File name for male animal profiles if variability used		file.rec	File created using InraPorc® based on description in sheets 3 or 4
File name for femelle animal profiles if variability used		file.rec	File created using InraPorc® based on description in sheets 3 or 4
Number of batches simulated		30	Fixed to 30 for simulations

Fig 2: Examples of static inputs of management practices, room characteristics and pig's characteristics for the ThermiPig model

TABLE 1 - Feeding conditions

Feeding level		AD LIBITUM
Feeding system	Choose	dry
Type of feeder	Choose	double space
Feed presentation	Choose	pelletes

TABLE 2 - Type of pig and average performance

Variable	unit	Profile name	
Type of sow		LWxLD	
Type of sire		PP	
Sex	Choose	mixed (2+3)	
Initial age	days	70	
Initial body weight	kg	27,9	(BW measured on D69)
Final age	days	167	
Final body weight	kg	124,1	
Average daily feed intake	kg/d	2,49	
Average daily gain	g/d	992	
Feed conversion ratio	kg/kg	2,52	
Slaughtering decision	Choose	other	COVID19 crisis
Description if other?		batch 542	
Number of departure for the slaughter house		1	again due to COVID19 crisis
Age at the first departure	days	167	
Carcass yield, %	%		
Lean content			
Comment on method of carcass grading:			

TABLE 3 - agenda and average data recorded per period

Beginning of the fattening period	dd mmm yyyy	25 Feb 2009					
#REFERENCE!		Diet 1	Diet 2				TOTAL
Number of pigs							
Initial age	days	70	118				
Initial body weight	kg	27,9	75,8				
Final age	days	118	167				
Final body weight	kg	75,8	124,1				
Duration	days	48	49				97
Cumulated amount of feed intake	kg/pig	106,4	135,6				242
Average daily intake	kg/pig	2,22	2,77				

Fig 3: Example of static inputs of feeding conditions and pig performance characteristics for the ThermiPig model

day (yyyy-mm-dd)	hour	Probe_Outdoor_Temperature	Probe_Outdoor_Relative_humidity	Probe_Indoor_temperature	measured_CO2	measured_NH3	Fan_T_setpoint	Fan_rate_min	Fan_rate_max	Fan_T_range
2019-10-01	1	11,3	82	24			24	10	100	6
2019-10-01	2	12,9	69	23,9			24	10	100	6
2019-10-01	3	13,3	53	23,8			24	10	100	6
2019-10-01	4	13	54	23,8			24	10	100	6
2019-10-01	5	12,8	56	24			24	10	100	6
2019-10-01	6	11,6	59	24			24	10	100	6
2019-10-01	7	11,2	63	23,9			24	10	100	6
2019-10-01	8	10,9	67	23,8			24	10	100	6
2019-10-01	9	13	60	24			24	10	100	6
2019-10-01	10	13,9	58	24			24	10	100	6
2019-10-01	11	14,5	60	23,9			24	10	100	6
2019-10-01	12	14,6	60	23,9			24	10	100	6

Fig 4: Examples of dynamic inputs of hourly observations of climate key variables for the ThermiPig model