

Extracting video-based phenotypes in a pig breeding programme

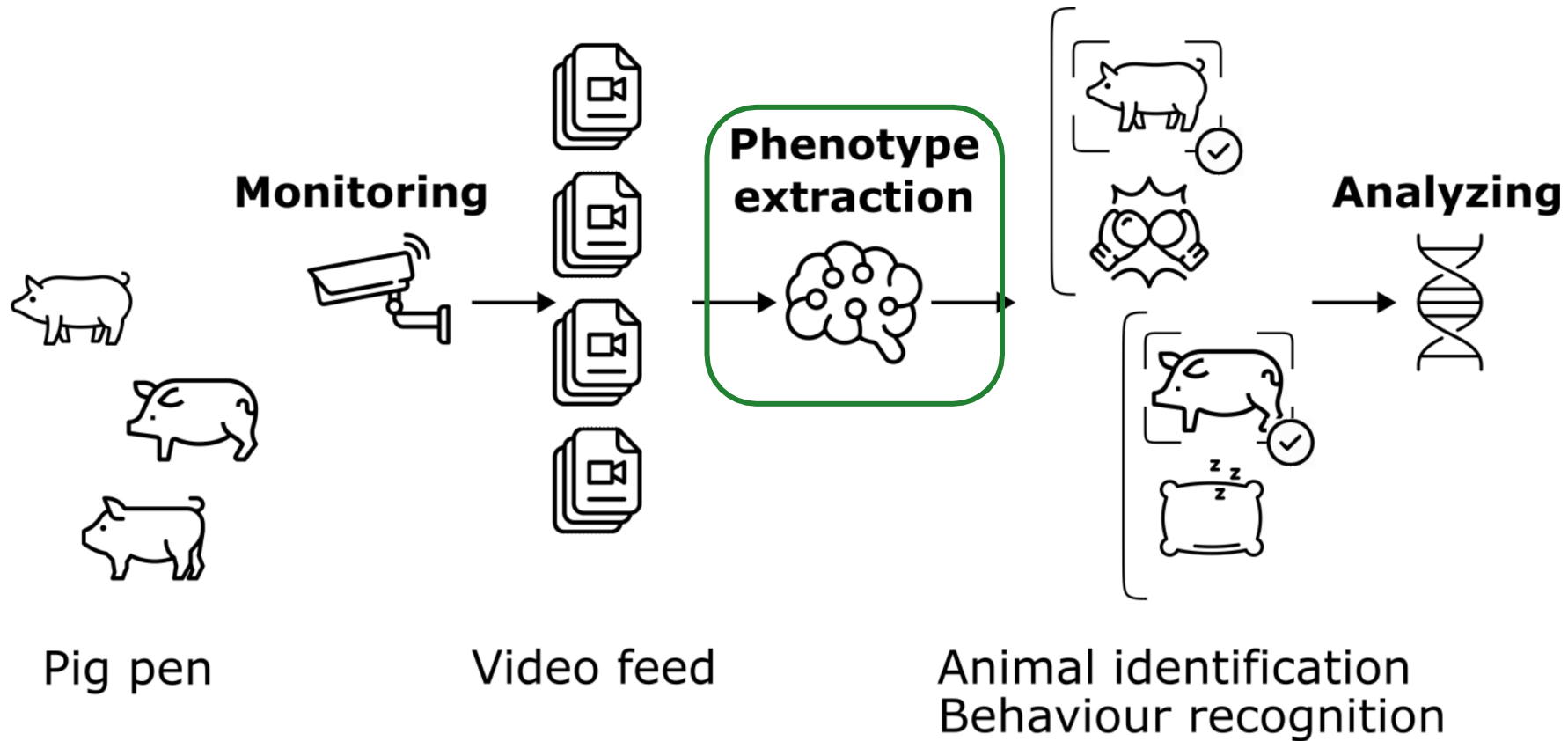
2023 - 08 - 26, Christopher Coello

Abstract# 41166



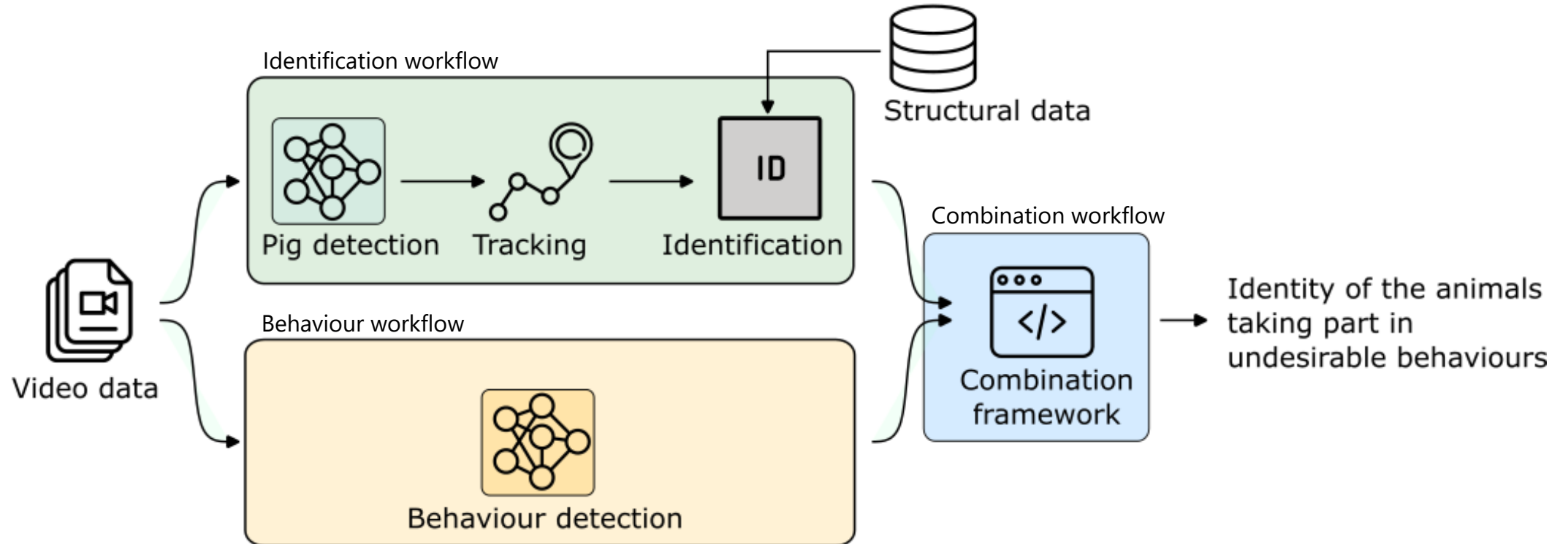
Project: Genes2Behave

Norwegian research council grant for 4 year project led by Kristin Hov Martinsen:
«build a pipeline using videos of pig behavior in a commercial farm setting,
extract novel traits or features and use these for genetic evaluation of animals»



Use case description and technical approach

Detect undesirable behaviours in housed pigs and identify the animals taking part in the detected behaviour



Dataset

- Animals :
 - Only males, Norwegian Landrace and Duroc
 - Housed in pens of 11 animals
 - Test period: around 110 days, from 30kg to 120kg
 - Installed 18 cameras, started recording and storing 24/7 in summer 2021

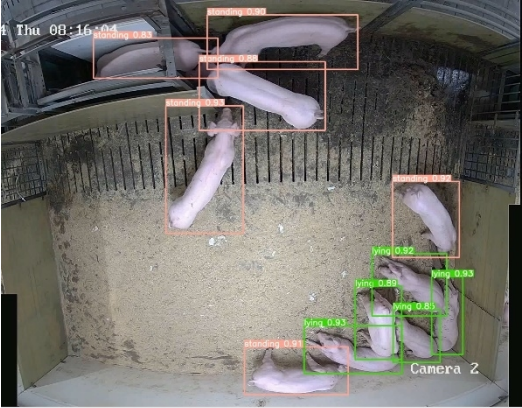


Pig detection - training



```

1 0.370536 0.142763 0.173363 0.0986842 0.828161
5 0.734003 0.825658 0.0654762 0.130263 0.845041
1 0.518973 0.235855 0.175595 0.169079 0.877289
5 0.688804 0.79375 0.0647321 0.179605 0.889796
1 0.547247 0.103289 0.209821 0.134211 0.895935
1 0.566406 0.911513 0.144717 0.117763 0.910717
5 0.723958 0.700329 0.104167 0.153289 0.916717
1 0.747024 0.539474 0.093006 0.186842 0.921053
1 0.438616 0.416447 0.107887 0.313158 0.929088
5 0.7766 0.775987 0.0435268 0.191447 0.930161
5 0.645461 0.859539 0.136161 0.117763 0.932131
    
```



Annotated dataset

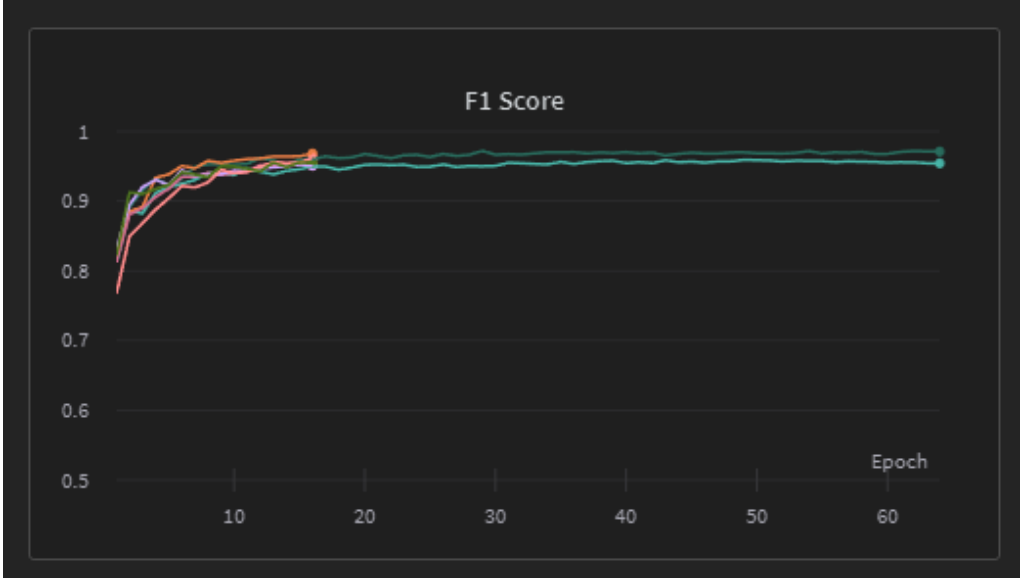
Images: 1800 images
 Videos: 108 minutes, 12960 images
 Total animals ~ 19K + 142K = **161K animals**

Training/validation dataset

Images: 1800 images
 Videos: 63 minutes, 7560 images
 Total animals ~ 19K + 83K = **102K animals**

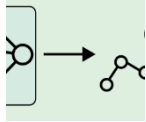
Cross-validation ->
 10 subsets of 80% randomly chosen form the training/validation dataset

Model training results



	mAP50-95	mAP50	F1score
CV average (64 epochs)	0.935	0.980	0.963

Pig detection - inference



```

1 0.370536 0.142763 0.173363 0.0986842 0.828161
5 0.734003 0.825658 0.0654762 0.130263 0.845041
1 0.518973 0.235855 0.175595 0.169079 0.877289
5 0.688804 0.79375 0.0647321 0.179605 0.889796
1 0.547247 0.103289 0.209821 0.134211 0.895935
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5 0.723958 0.700329 0.104167 0.153289 0.916717
1 0.747024 0.539474 0.093006 0.186842 0.921053
1 0.438616 0.416447 0.107887 0.313158 0.929088
5 0.7766 0.775987 0.0435268 0.191447 0.930161
5 0.645461 0.859539 0.136161 0.117763 0.932131
    
```

annotations



tabular data

id	sourceid	methodid	labelid	relative_id	x	y	w	h	conf_bbox	eartagid	conf_eartag	tracking_id	testnr
1	1	1	1	1	0.370536	0.142763	0.173363	0.0986842	0.828161	[NULL]	[NULL]	1	[NULL]
2	2	1	1	5	0.734003	0.825658	0.0654762	0.130263	0.845041	[NULL]	[NULL]	2	[NULL]
3	3	1	1	1	0.518973	0.235855	0.175595	0.169079	0.877289	[NULL]	[NULL]	3	[NULL]
4	4	1	1	5	0.688804	0.79375	0.0647321	0.179605	0.889796	[NULL]	[NULL]	4	[NULL]
5	5	1	1	1	0.547247	0.103289	0.209821	0.134211	0.895935	[NULL]	[NULL]	5	[NULL]
6	6	1	1	1	0.566406	0.911513	0.144717	0.117763	0.910717	[NULL]	[NULL]	6	[NULL]
7	7	1	1	5	0.723958	0.700329	0.104167	0.153289	0.916717	[NULL]	[NULL]	7	[NULL]
8	8	1	1	1	0.747024	0.539474	0.093006	0.186842	0.921053	[NULL]	[NULL]	8	[NULL]
9	9	1	1	1	0.438616	0.416447	0.107887	0.313158	0.929088	[NULL]	[NULL]	9	[NULL]
10	10	1	1	5	0.7766	0.775987	0.0435268	0.191447	0.930161	[NULL]	[NULL]	10	[NULL]
11	11	1	1	5	0.645461	0.859539	0.136161	0.117763	0.932131	[NULL]	[NULL]	11	[NULL]
12	12	2	1	1	0.367746	0.142763	0.158854	0.0960526	0.783821	[NULL]	[NULL]	1	[NULL]
13	13	2	1	5	0.733817	0.826974	0.0658482	0.123684	0.840754	[NULL]	[NULL]	2	[NULL]
14	14	2	1	1	0.522879	0.238816	0.167039	0.163158	0.896045	[NULL]	[NULL]	3	[NULL]
15	15	2	1	5	0.680432	0.79375	0.0639881	0.179605	0.89657	[NULL]	[NULL]	4	[NULL]
16	16	2	1	1	0.542783	0.102303	0.21131	0.132237	0.899203	[NULL]	[NULL]	5	[NULL]
17	17	2	1	1	0.56622	0.911184	0.144345	0.118421	0.899893	[NULL]	[NULL]	6	[NULL]

Inference: data amount

Full test period: 110 days -> 1430 hours (8h->21h)

1h ~ 1G video -> **1.43 TB of video to analyse for 11 animals**

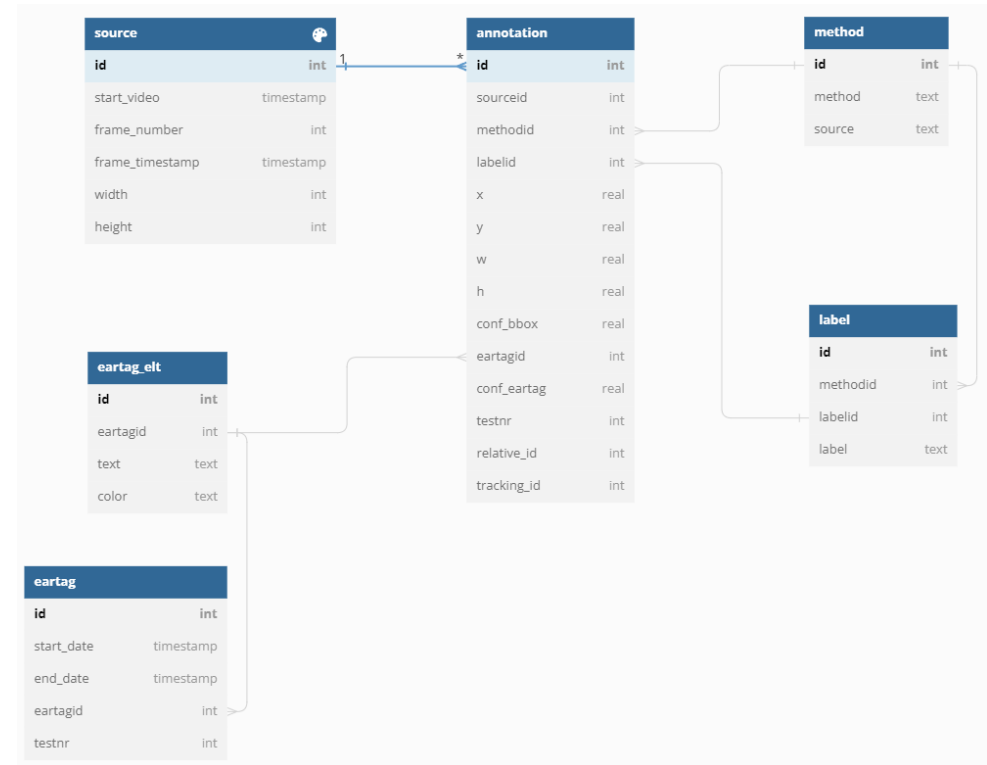
1000 animals -> 1300 TB of video to analyse

Inference: practical implementation

Output model -> files with numbers

Need to

- **give context** to these numbers by relating them to classes, acquisition time of the video, pen, department, etc...
- make contextualized results **available** to the next module
- ease of **debugging / monitoring** of the module



Creation of a data model

Tracking - evaluation



Dataset : 6 videos (2 fps)

- V1: 30min -> used for training of detection model
- V2: 10min -> used for training of detection model
- V3: 5min -> used for training of detection model
- V4: 25min -> used for training of detection model
- V5: 15min -> used as validation for tracking
- V6: 25min -> used as validation for tracking

V5 : 11 tracks of 1800 timesteps (15*60*2)

V6 : 11 tracks of 3000 timesteps (25*60*2)

One image

What the models automatically predict

123 id	123 sourceid	123 methodid	123 labelid	123 relative_id	123 x	123 y	123 w	123 h	123 conf_bbox	123 eartagid	123 conf_eartag	123 tracking_id	123 testnr
1	729	67	1	5	0.736607	0.823355	0.061756	0.1375	0.492149	[NULL]	[NULL]	2	[NULL]
2	730	67	1	5	0.747954	0.704934	0.0680804	0.249342	0.648207	[NULL]	[NULL]	7	[NULL]
3	731	67	1	1	0.681548	0.784868	0.077381	0.184211	0.681305	[NULL]	[NULL]	4	[NULL]
4	732	67	1	1	0.327939	0.162171	0.207217	0.109868	0.783748	[NULL]	[NULL]	5	[NULL]
5	733	67	1	5	0.479911	0.339145	0.0885417	0.298026	0.891399	[NULL]	[NULL]	9	[NULL]
6	734	67	1	1	0.749442	0.450987	0.114955	0.250658	0.900644	[NULL]	[NULL]	8	[NULL]
7	735	67	1	1	0.572731	0.876645	0.106771	0.194079	0.901936	[NULL]	[NULL]	6	[NULL]
8	736	67	1	1	0.593378	0.698684	0.115327	0.219737	0.904001	[NULL]	[NULL]	1	[NULL]
9	737	67	1	1	0.496652	0.210855	0.196429	0.1875	0.914076	[NULL]	[NULL]	3	[NULL]
10	738	67	1	5	0.778832	0.780263	0.0412946	0.197368	0.915352	[NULL]	[NULL]	10	[NULL]
11	739	67	1	5	0.65811	0.864474	0.119048	0.119737	0.931073	[NULL]	[NULL]	11	[NULL]
12	33,276	67	2	1	0.910732887	0.87697368	0.1196765395	0.486515789	1	[NULL]	[NULL]	1	[NULL]
13	33,277	67	2	1	0.060918899	0.537467105	0.1794084821	0.146644737	1	[NULL]	[NULL]	2	[NULL]
14	33,278	67	2	6	0.060918899	0.537467105	0.1794084821	0.146644737	1	[NULL]	[NULL]	2	[NULL]
15	33,279	67	2	1	0.958296131	0.045164474	0.1907366071	0.046644737	1	[NULL]	[NULL]	3	[NULL]
16	33,280	67	2	1	0.805636161	0.413223684	0.3881436012	0.081447368	1	[NULL]	[NULL]	4	[NULL]
17	33,281	67	2	1	0.519810268	0.437697368	0.134281894	0.595131579	1	[NULL]	[NULL]	5	[NULL]
18	33,282	67	2	1	0.435714286	0.089835526	0.3762425595	0.545197368	1	[NULL]	[NULL]	6	[NULL]
19	33,283	67	2	3	0.700074405	0.738486842	0.3530357143	0.872236842	1	[NULL]	[NULL]	7	[NULL]
20	33,284	67	2	1	0.672916667	0.915559211	0.123110119	0.041644737	1	[NULL]	[NULL]	8	[NULL]
21	33,285	67	2	3	0.440643601	0.635460526	0.1401450893	0.268157895	1	[NULL]	[NULL]	9	[NULL]
22	33,286	67	2	1	0.794103423	0.876513158	0.3725037202	0.905526316	1	[NULL]	[NULL]	10	[NULL]
23	33,287	67	2	3	0.315215774	0.169473684	0.3723660714	0.313684211	1	[NULL]	[NULL]	11	[NULL]

Ground truth: annotations



Multiple object tracking accuracy (MOTA) , identity switches (IDs), etc...

Tracking - results

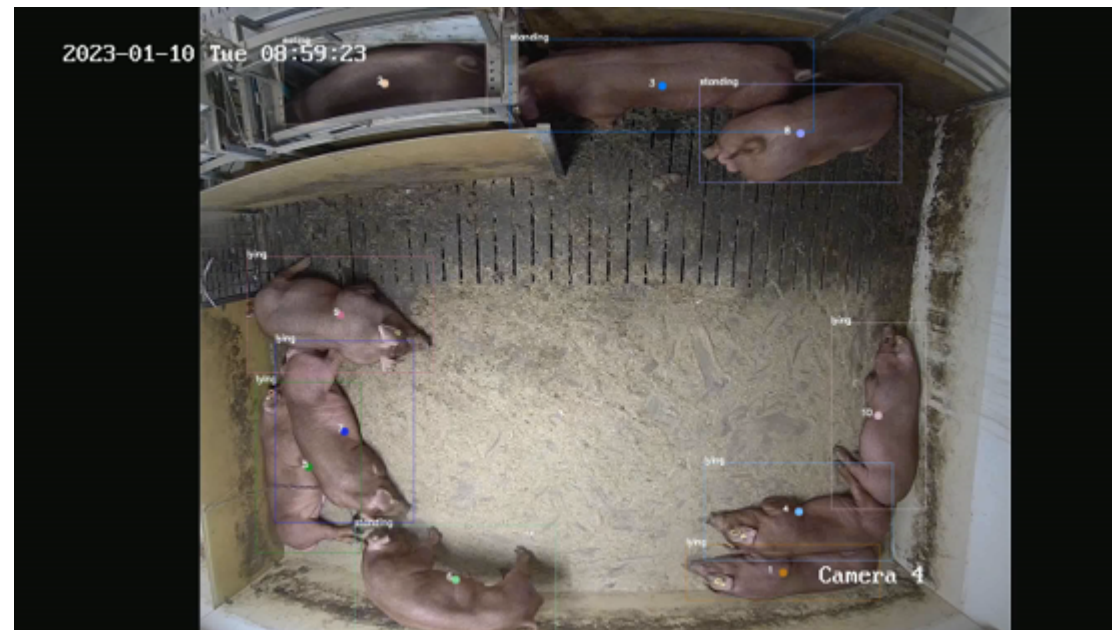
Algorithmic constraints

- Number of animals in the pen is known
- The initial frame is correct: all animals are detected

		MOTA	IDs
V5	0->5min	94.8	0
	5->10min	92.1	10
	10->15min	91.9	0
V6	0->5min	92.4	35
	5->10min	92.5	71
	10->15min	97.1	24
	15->20min	94.6	42
	20->25min	98.2	62

MOTA : multiple object tracking accuracy

IDs : identity switches



Identification - description



ID	Species	Sex	Age	Weight	Height	Length	Width	Depth	Volume	Color	Texture	Shape	Position	Orientation	Velocity	Acceleration	Angular Velocity	Angular Acceleration
1	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
7	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
9	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

tabular data



tabular data

ID	Species	Sex	Age	Weight	Height	Length	Width	Depth	Volume	Color	Texture	Shape	Position	Orientation	Velocity	Acceleration	Angular Velocity	Angular Acceleration
1	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
7	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
9	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10	101	1	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Colocalisation of an animal location in the feeding station



if yes

Query the feed data for temporal match

if yes

Assign the ID to the animal in the feeding station

if tracked

Propagate the ID to the whole track



1 ID = 1 track



Same track gets assigned two or more IDs

An ID is assigned to two different tracks

Identification – how to validate ?



12 Nov 2022

08:08

20:40

752 minutes

No ground truth -> need statistical approach to convince us of the validity of the results

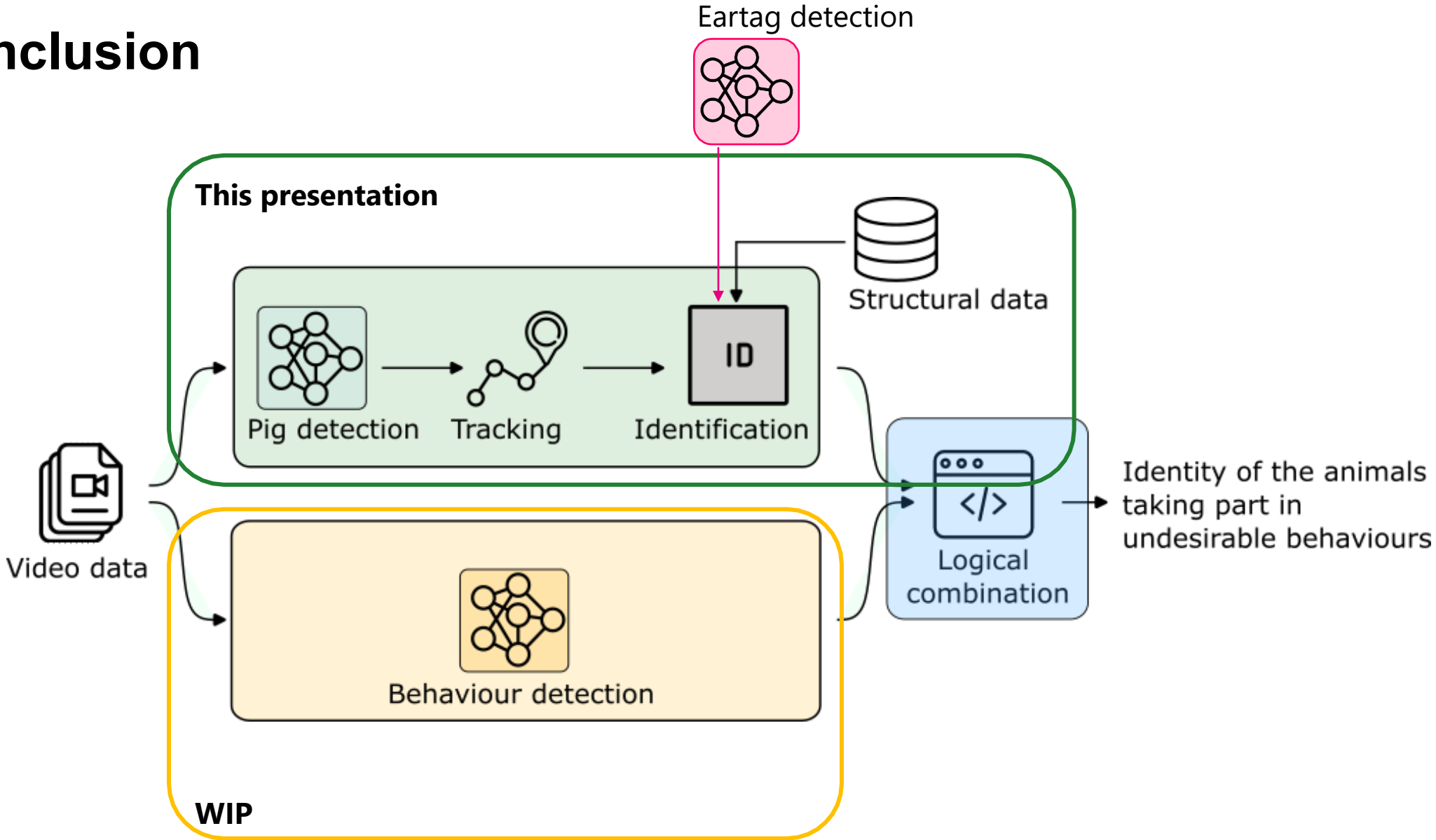
11 animals -> how often each animal is identified during the analyzed period ?

Animal ID	46244	46245	46246	46247	46248	46249	46250	46251	46252	46253	46254
# frames detected	26420	9668	14563	13741	7978	26140	63391	31491	8005	18078	25363
Period detected (min)	220	81	121	114	66	218	528	262	68	151	211
% analyzed period	29.3	10.7	16.1	15.2	8.8	29.0	70.2	34.9	8.9	20.0	28.1

large difference

Animal ID	46244	46245	46246	46247	46248	46249	46250	46251	46252	46253	46254
Median time between 2 feed events (min)	184	14	38	60	100	23	137	20	39	39	33

Conclusion





Norsvin