Vision-based Behavioral Recognition of Novelty Preference in Pigs

Aniket Shirke, Rebecca Golden, Mrinal Gautam, Angela Green-Miller, Matthew Caesar, Ryan N. Dilger

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

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Introduction:

- Video-dependent research is bottlenecked on the analysis of data.
- Deep Learning methods can be used to expedite video analysis.
- We apply deep learning in Animal Sciences' research to minimize human intervention for video analysis.

Novel Object Recognition (NOR) task:

- An NOR task is used to assess recognition memory in pigs, where an individual pig is freely allowed to explore an arena that contains one familiar object and one novel object for 5 minutes.
- As an important behavioral assessment, ten or more pigs are typically tested in each experimental group, and the pigs' interactions with objects are used to extract specific metrics:

N	Number of investigations
CD	Total time spent investigating
ME	Average amount of time spent for one investigation
LF	Latency to first investigation
LL	Latency to last investigation
RI	Amount of time spent investigating the novel object proportional to the total amount of time investigating

Problem:

Each 5-minute video takes **30 minutes** of manual analysis to extract the required metrics

Solution:

We trained three action recognition models to predict pig behavior

1. LRCN: "Long-term Recurrent Convolutional Networks for Visual Recognition and Description", Donahue et al.
2. C3D: "Learning Spatio-Temporal Features With 3D Residual Networks for Action Recognition", Hara et al.
3. TSM: "TSM: Temporal Shift Module for Efficient Video Understanding", Lin et al.

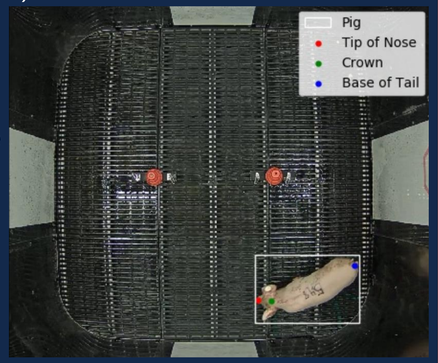
Pig Novelty Preference Behavior (PNPB) dataset:

The PNPB dataset contains a total of 20 videos which were collected at the Pig Nutrition and Cognition Lab (PNCL).

It contains annotations for the following tasks:

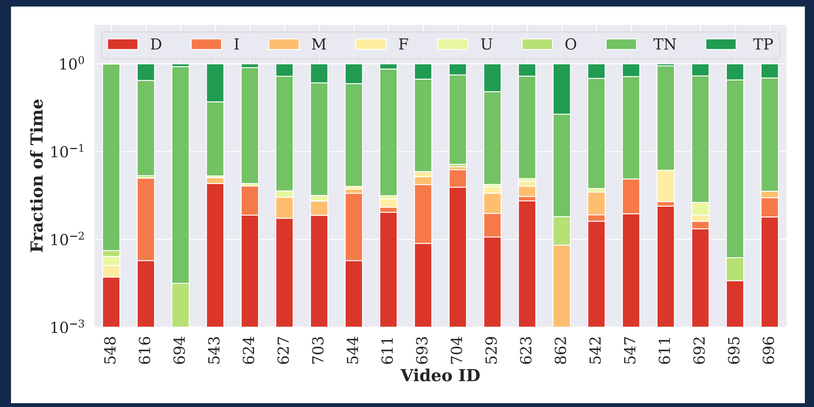
Action Recognition: Time intervals for object investigations made by the pig were manually annotated.

Keypoint Detection: The base of the tail, the tip of the nose, the crown of the head, and a bounding box for the whole pig were annotated for 668 frames.



Is Deep Learning comparable to Human scorers?

We measured continuous action recognition performance for the best model (TSM) and visualized different types of errors described in "Performance metrics and evaluation issues for continuous activity recognition", Minnen et al. On average, a severe error was made 3% of the time.



Statistic	N	CD	ME	LF	LL	RI
Mean	24.15	113.06	4.72	5.69	316.83	0.49
R^2	0.58	0.99	0.77	0.42	-0.26	0.86
Mean Error	-4.00	-1.74	0.90	2.49	-6.72	-0.03
Std Error	3.3	6.35	1.23	5.37	35.25	0.07

- Treating the extraction of metrics as a regression problem, the R^2 of all the metrics were computed. Ideally, a researcher would prefer a deep learning pipeline that predicts metrics with an R^2 of at least 0.99.
- The model underestimated the number of investigations due to its inability to capture investigations that last less than one second.
- A naive application of state-of-the-art action recognition models is not sufficient to match the level of human annotators.

Future Goals:

- We intend to utilize the keypoint data to build a deep learning pipeline with an increased accuracy in predicting NOR metrics.
- Our goal is to expand the pig surveillance dataset based on ethograms and offload deep learning models on Edge Computing devices in order to expedite research in this domain.

Summary:

- We introduced a fully annotated 'Pig Novelty Preference Behavior' (PNPB) dataset, where the goal was to match the prediction accuracy of deep learning models to that of a human annotator.
- Even though the application of state-of-the-art action recognition models achieved 95% accuracy in classifying short clips of pig behavior, the current models cannot be applied in an end-to-end pipeline to extract domain-specific metrics.
- Code: https://github.com/AIFARMS/NOR-behavior-recognition

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