Development and Integration of Artificial Intelligence
Technologies for Innovation Acceleration

Innovation in management of breeding cows

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Background

High demand on **smart agriculture** to improve productivity based on scientific knowledge and data

In livestock field, detecting estrus and grasping the health condition and stress of cows are very important

Typical methods

- Collect and analyze information of individual livestock
  (e.g. blood test, pedometer, implanted thermometer, etc.)

Problems

- Difficulties in detecting weak or non-visible changes of health/stress condition and estrus
- Stress induced by measurement itself
- Cost of measurement/test (labor costs)

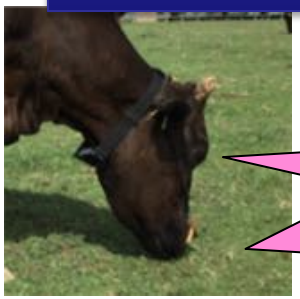
Our solution: IoC (Internet of Cows)

Our project

- Cows are **social animals** which build community
- **From "grasping individual cow's condition" to "grasping cow's condition through interaction affected by their instincts"**

Video Camera
(Time-series Bird's Eye Image)

BLE Tag
- *Signal Strength*
- *Acceleration, Air Pressure*
- *Individual Recognition*

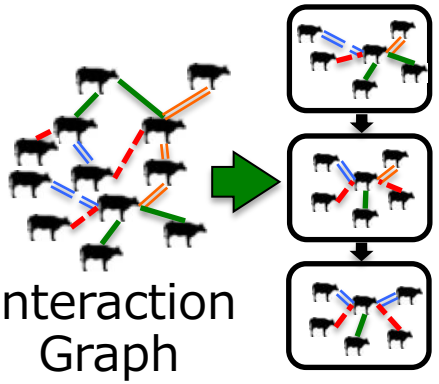


Extraction of diverse multi-layer interaction

Interaction
- Physical Contact
  Types
- Approach
  Time length, direction
- Synchronous Behavior
  Time length, direction

etc.

Community Extraction



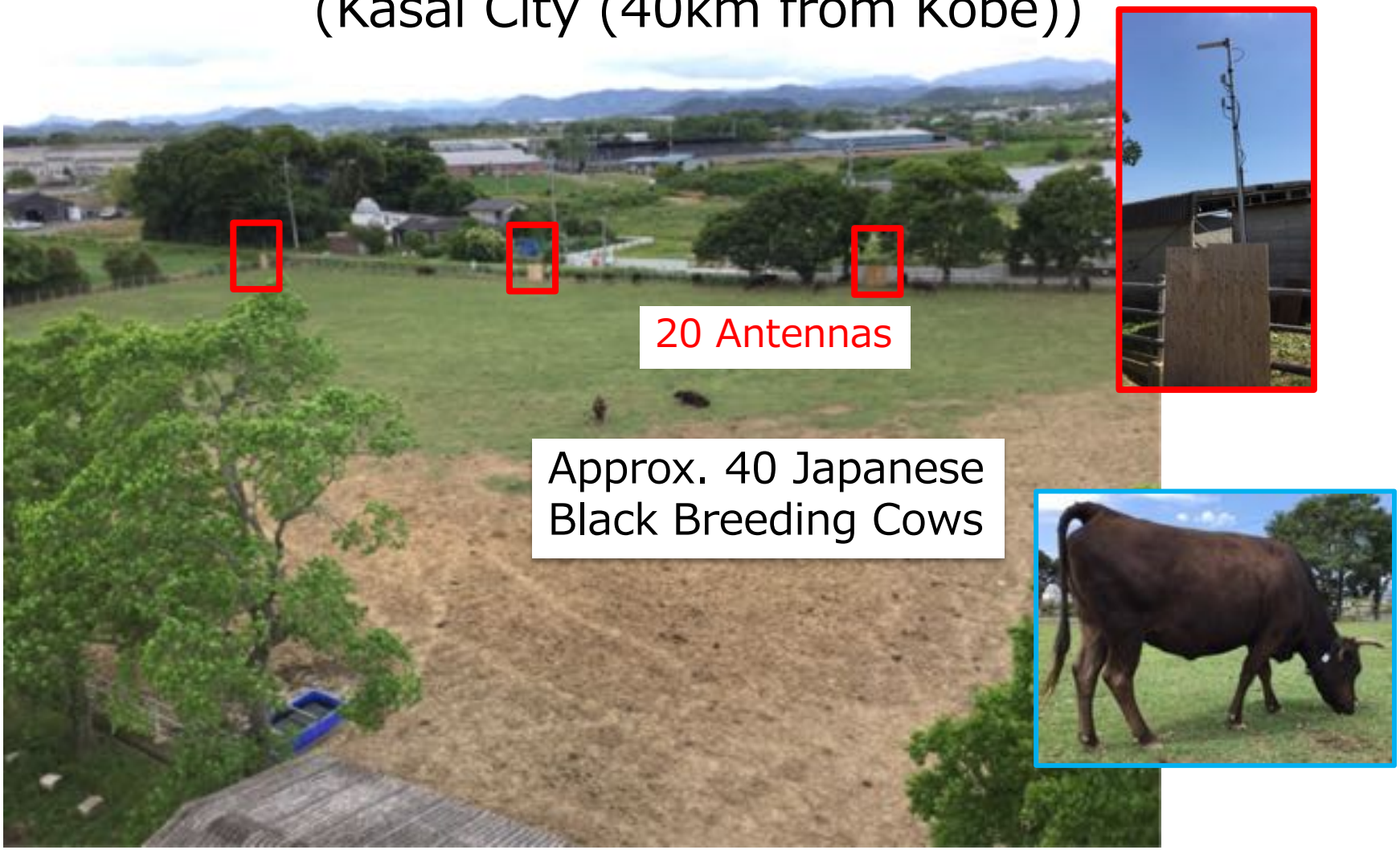
Analysis of the changes of cow's interaction, community and condition

Innovation in cow breeding industry

- Automatic health & estrus detection
- Pre-empt care for **signs of** illness/stress
- **Weak/non-visible** estrus detection

Experimental Field

Food Resources Education and Research Center, Kobe Univ.
(Kasai City (40km from Kobe))



Current achievements in the project

Integration of AI, Networking, and Agricultural Knowledge

(fat field) Prof. Ohta

- Track Cows using BLE tag and bird's eye image
  - Environment Preparation
  - Location estimation of cows using active BLE tags
  - Tracking cows using bird's eye image

(big mountain) Prof. Oyama

- Obtain various data to grasp the condition of cows
  - Estrus detection by visual observation (standing, unusual approach, mucus, vulva swelling, bleeding)
  - Find abnormal cows by saliva and blood test

(big river) Prof. Ohkawa

- Extract interaction and discover its significant change
  - Behavioral analysis from BLE tag data
  - Interaction based on synchronization and approaching
  - Relation with condition and change of interaction

Important points for verification
- Is it possible to grasp cow location with BLE tags?
- Is there a relation with cow's interaction and condition?

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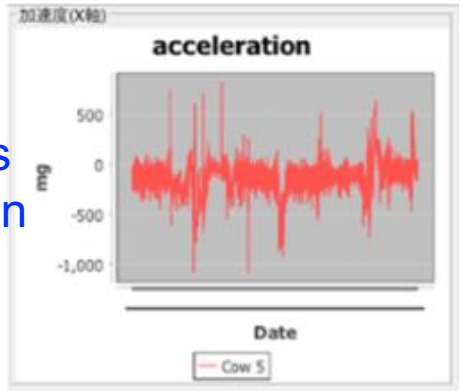
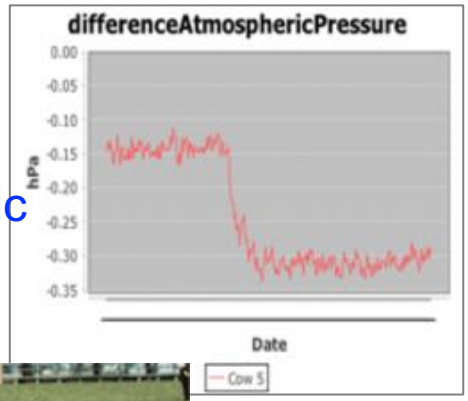
Interaction based on cow's synchronized behavior

Three-axis acceleration sensor



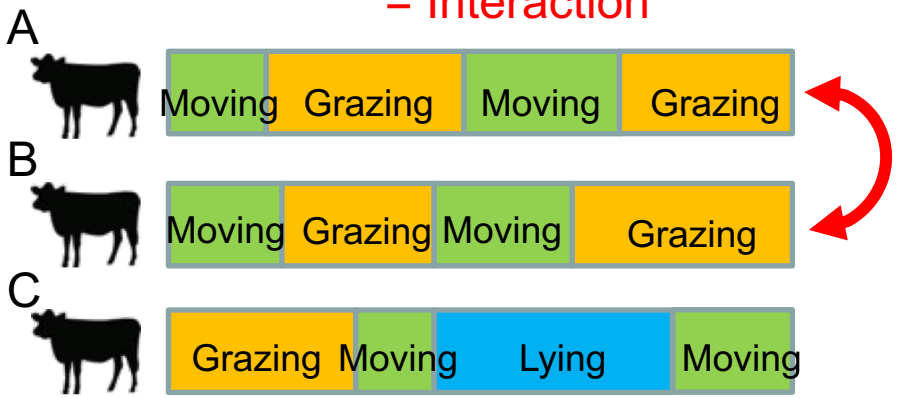
Atmospheric Pressure



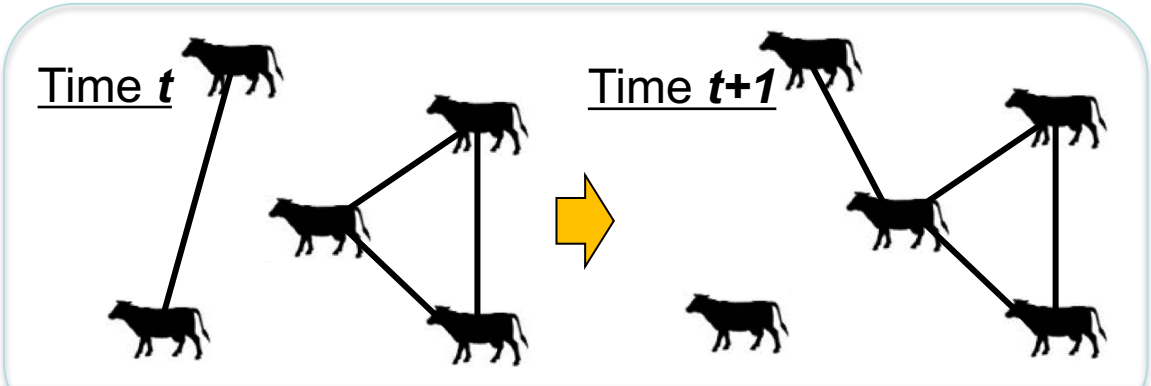
BLE tag

Behavior analysis from BLE tag data

Synchronized behavior = Interaction

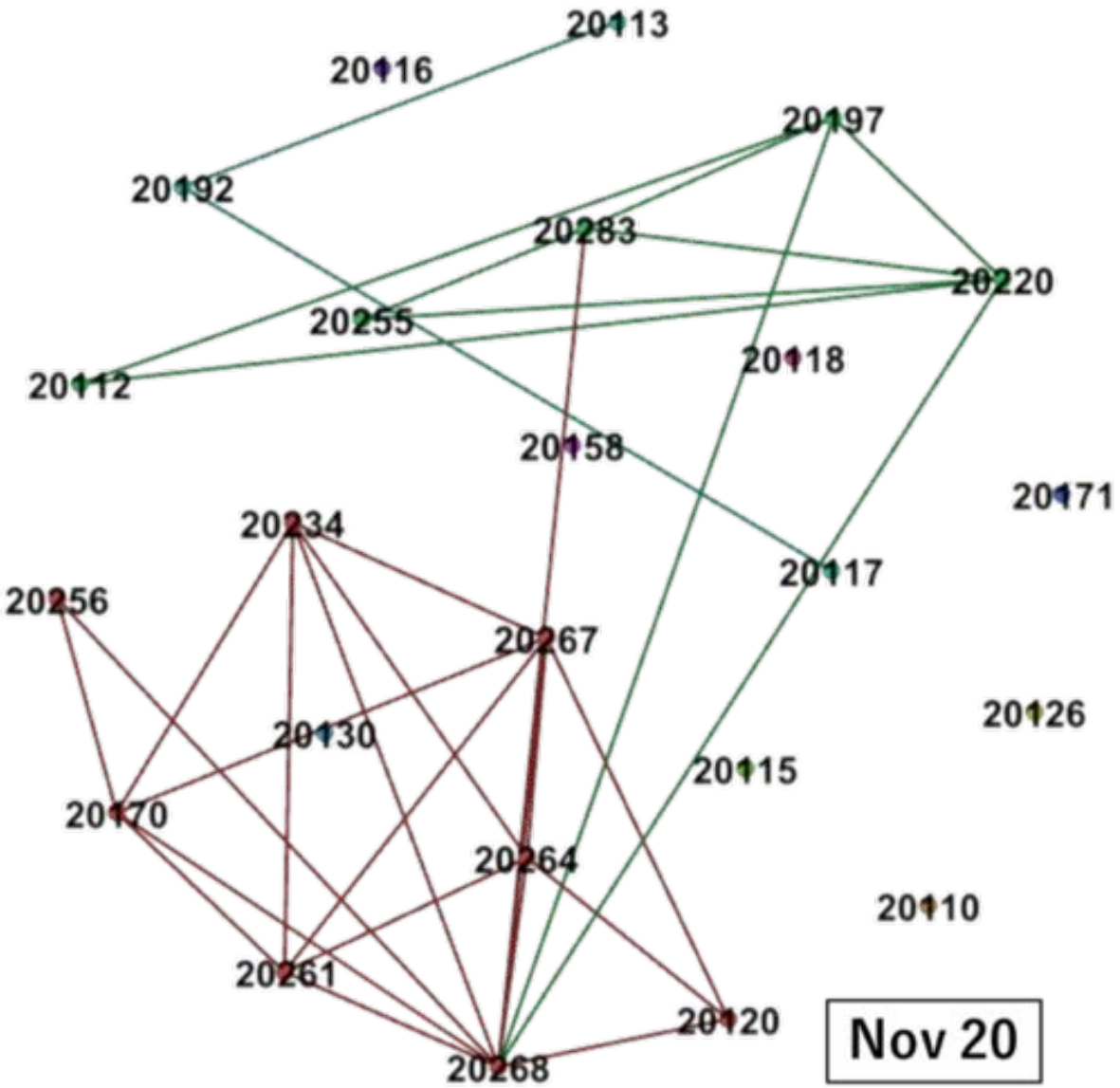


- Interaction graph construction
- Community extraction



Detect estrus and health condition based on the temporal change of communities (size and similarity)

Example of interaction graph



Extract communities from the interaction graph using Louvain method in which the modularity is locally optimized

Preliminary Result (1)

Interaction based on synchronized behavior and estrus

Temporal change of the size of the community

Cow ID:20267 (Nov. 1, 2017 – Nov. 31, 2017)

No special observation

Mucus was observed on Nov. 16
(= sign of estrus)

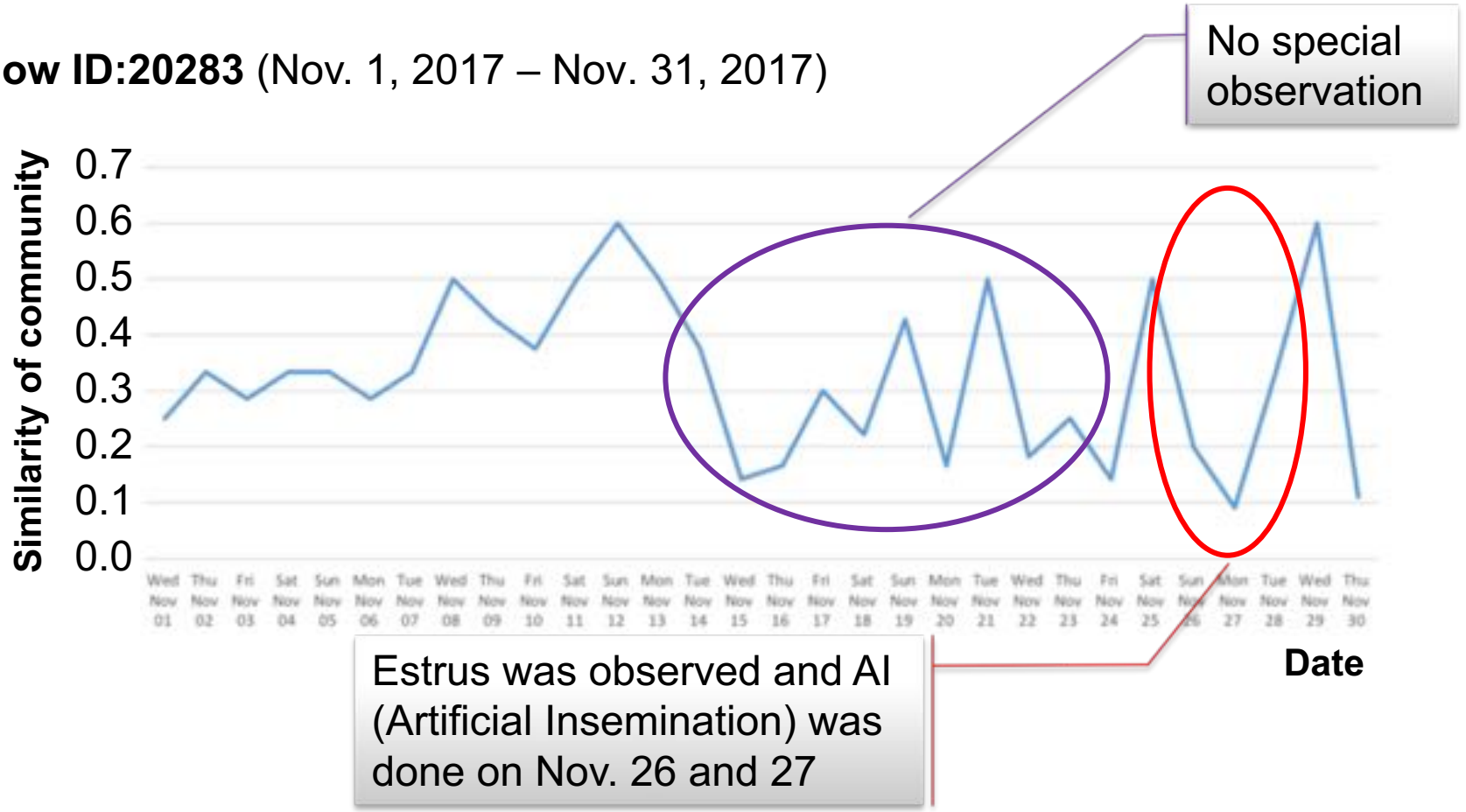
Preliminary Result (2)

Interaction based on synchronized behavior and estrus

Temporal change of the similarity of the community*

*Similarity between the current community and the community the cow normally belongs to

Cow ID:20283 (Nov. 1, 2017 – Nov. 31, 2017)



Stanchion order vs. community size

Stanchion order:

- the order of returning to the cowshed for getting food
- the strongest cow usually returns first, the weakest one returns last
- change of the order suggests estrus

Cow ID	20197	20192	20171	20113	20115	20110	20122	20126	20170	20267	20268
Rank	1	1	3	4	5	7	7	7	14	16	22

Strong ← → **Weak**

The rank of community size:

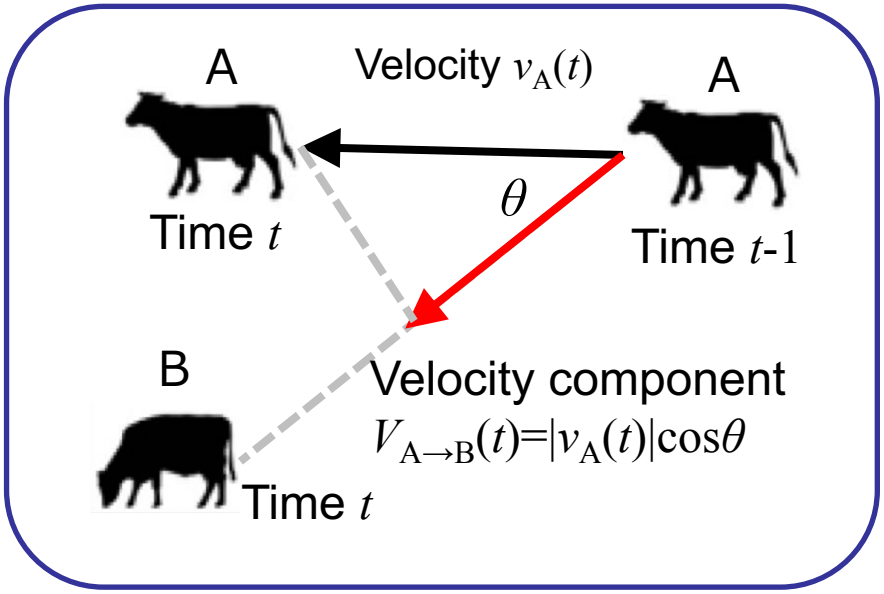
- the higher the rank is, the smaller the average size of community that the cow belongs to is

Cow ID	20197	20192	20171	20113	20115	20110	20122	20126	20170	20267	20268
Rank	1	3	6	5	6	3	9	9	17	20	23

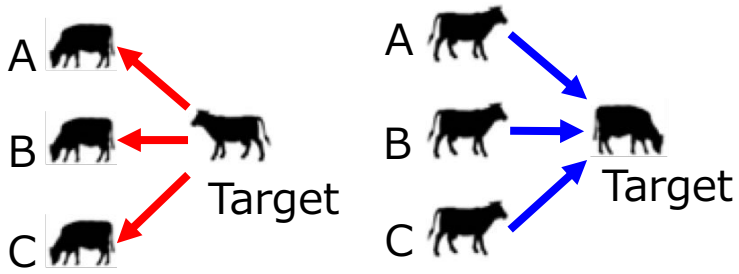
✓ **Strong cows** behave **independently**
✓ **Weak cows** hang around with **other weak cows**

Extract interaction from approach behavior

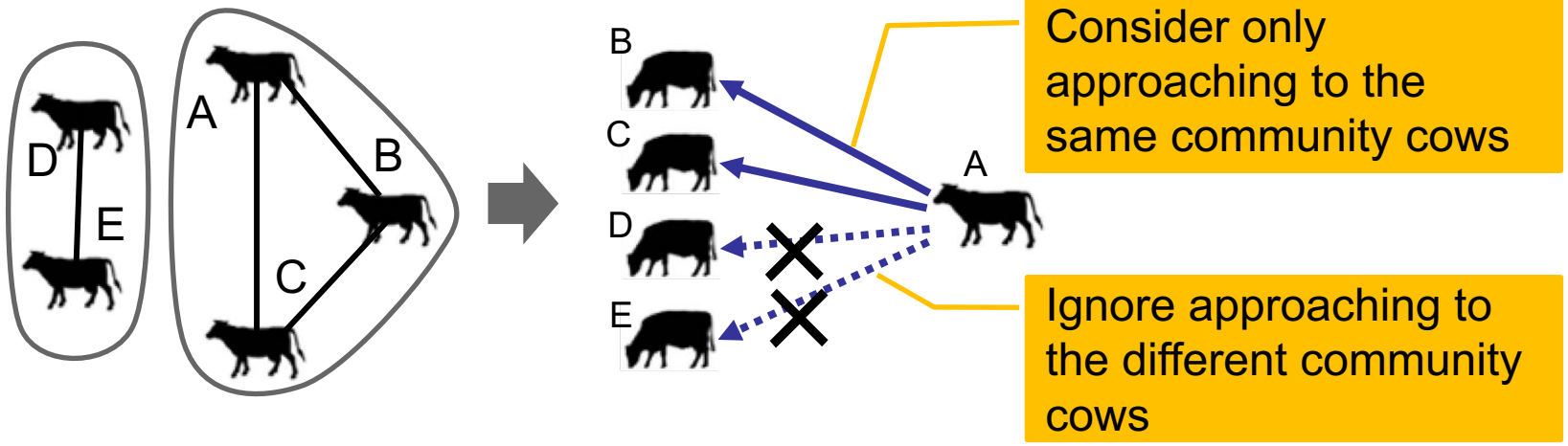
◆ Amount of Approach Calculation



Amount of approach
= Total of $V_{A\to B}(t)$ in time T



Approaching **Approached**
(Interest from other cows)



Consider only approaching to the same community cows

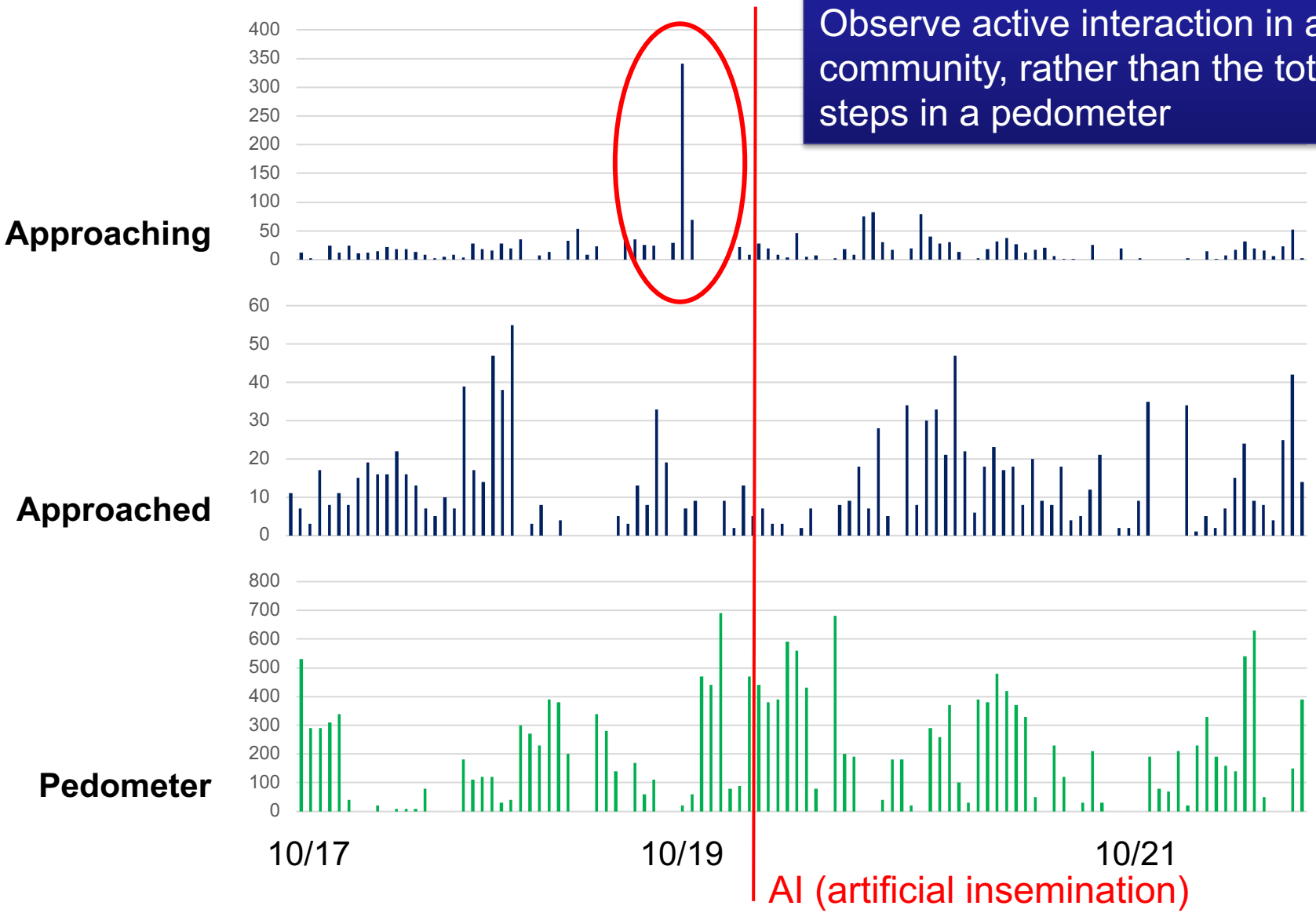
Ignore approaching to the different community cows

Preliminary Result (3)

Interaction from approach behavior and Estrus

Cow ID:20171 (Oct. 17, 2017 14:00 – Oct. 21, 2017 21:00)

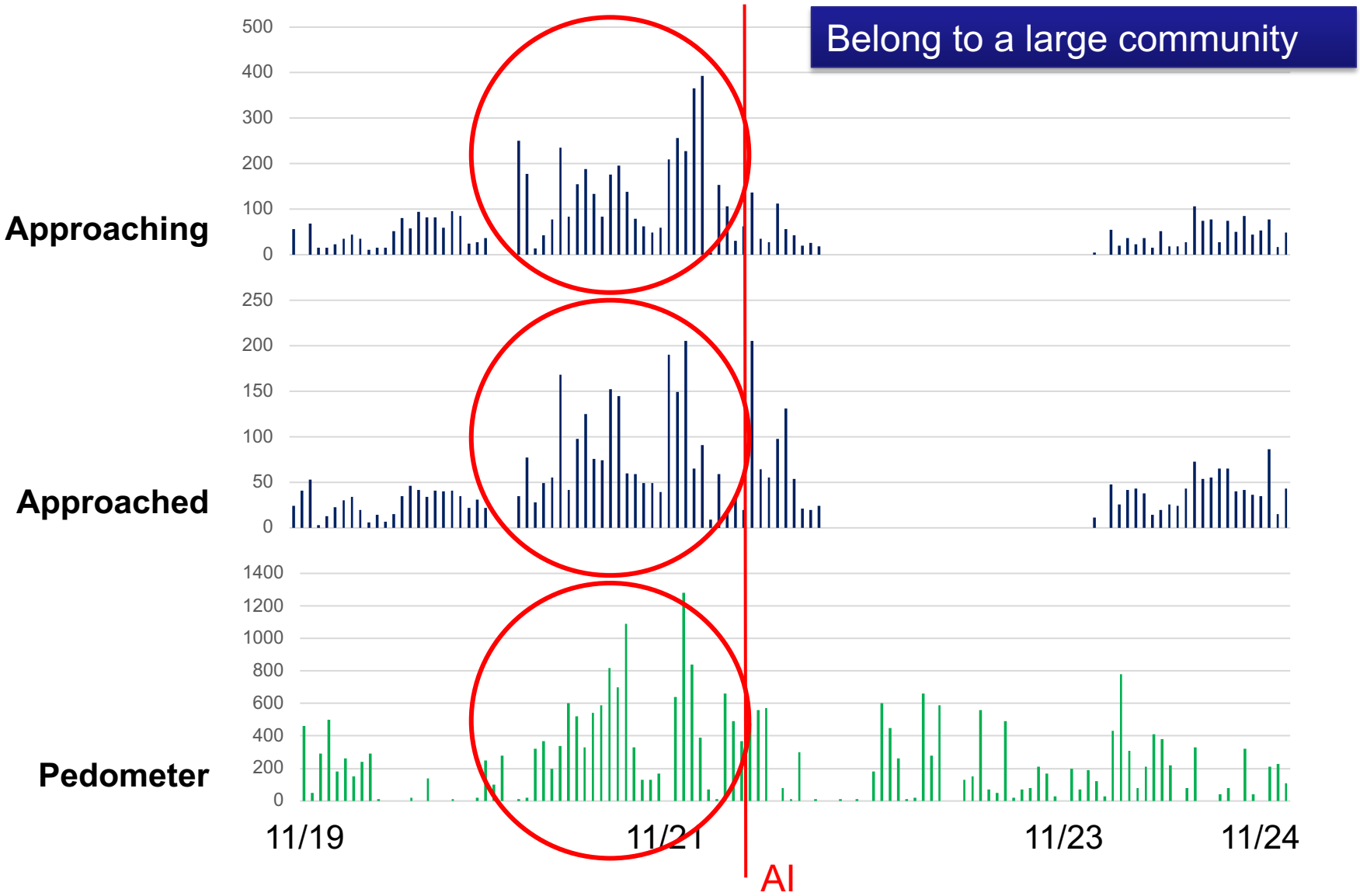
Observe active interaction in a community, rather than the total steps in a pedometer



Preliminary Result (4)

Interaction from approach behavior and Estrus

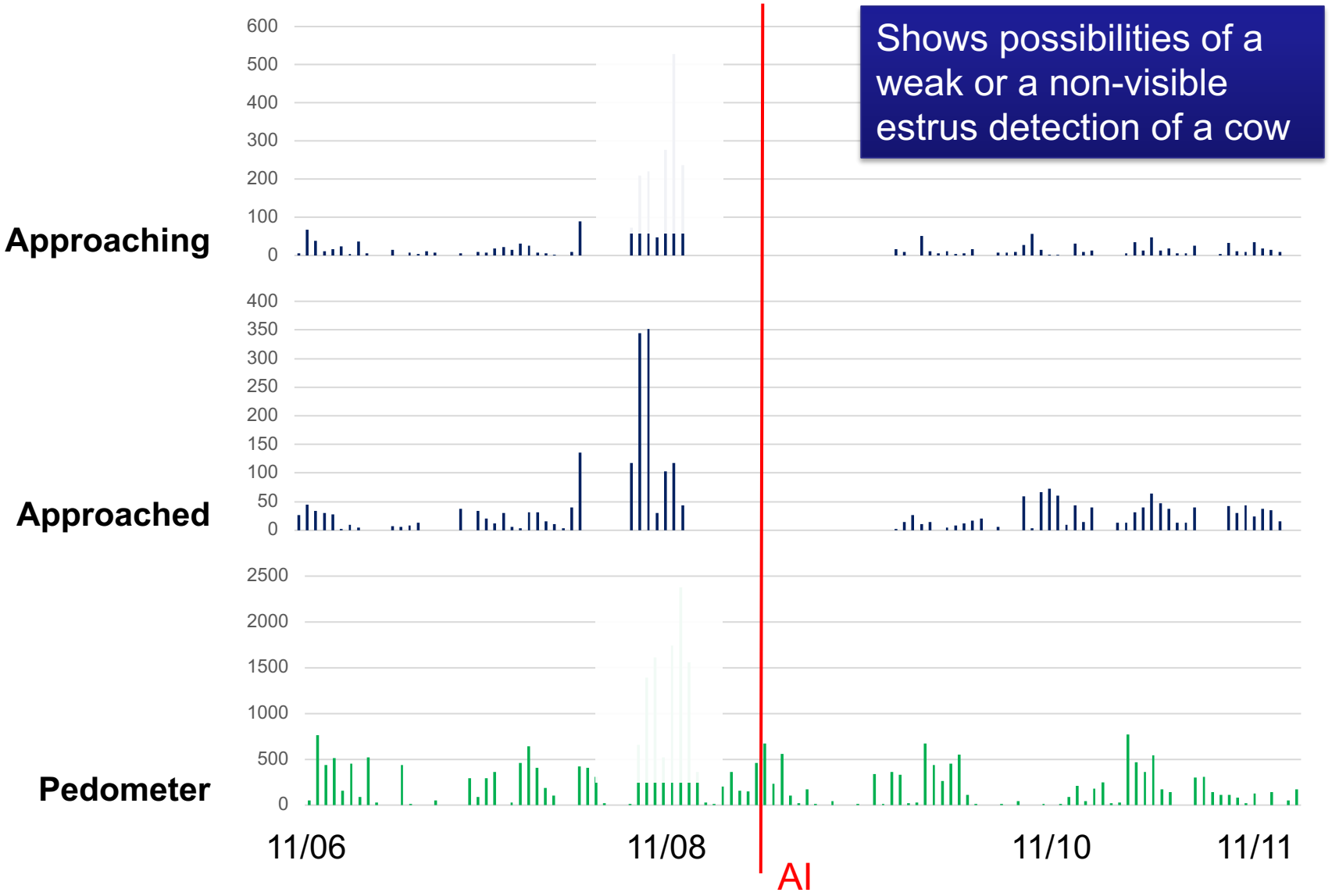
Cow ID:20220 (Nov. 19, 2017 09:00 – Nov. 24, 2017 09:00)



Preliminary Result (5)

Interaction from approach behavior and Estrus

Cow ID:20115 (Nov. 6, 2017 11:00 – Nov. 11, 2017 08:00)



Future Plans

Track cows using BLE tags and bird's eye image

- Improve the accuracy by increasing resolution of virtual space
- Verification using BLE tags equipped on cows
- Use complementarily with bird's eye image

Obtain various data to grasp the condition of cows

- Acquire data continuously

Relevance evaluation of cow's condition & interaction

- Refinement of interactions
- Automatic classification of behaviors
- Find abnormal cow by analyzing the community change
- Accuracy evaluation by increasing the number of data
- Interpretation from the viewpoint of ethology


Thank you for your
kind attention!