

MATLAB EXPO

2024.06.11 | 그랜드 인터컨티넨탈 서울 파르나스

Development of Deep Learning and Machine Learning Models for Anomaly Detection in Livestock and Human Infectious Diseases Using MATLAB

MATLAB을 활용한 축사 내 이상 및 사람 감염병 감지를 위한 딥러닝/머신러닝 모델 개발

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김유진 책임연구원, 한국전자통신연구원



Contagion(2011)

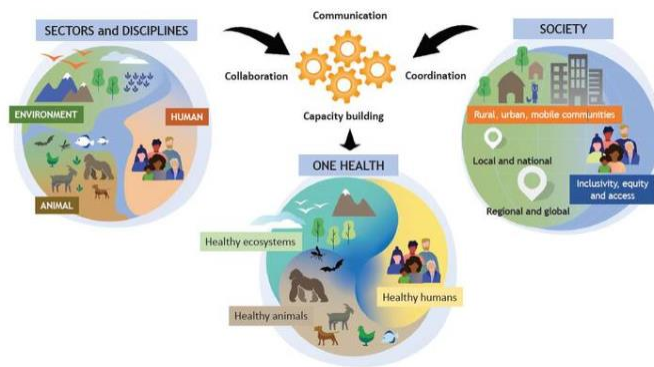
Play Videoclip

<https://youtu.be/vWwms7Peqng?si=vCShvjwRfZQgO5pl>



What are your thoughts on the relationship between One Health and MATLAB?

Topic 1



One Health

[Image Credit]

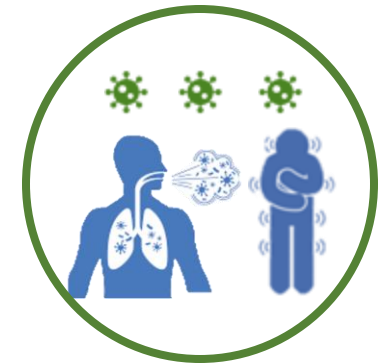
https://www.onehealthcommission.org/en/why_one_health/what_is_one_health/

Topic 2



Anomaly Detection for Pigs

Topic 3



Predicting Antigen Concentration in Rapid Kits (Influenza A/B, COVID-19)

Topic 1: One Health

Parallel Pandemics

두 개 이상의 전염병이 동시에 발생하고 서로에게 영향을 미치는 현상

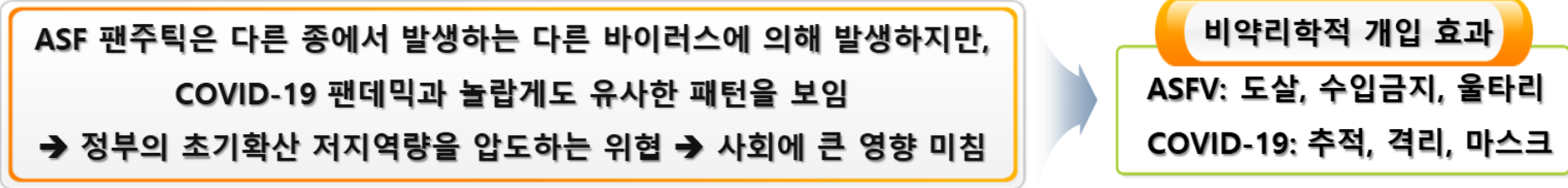
▣ 병렬전염병

예-1: COVID-19 팬데믹 진행동안 젊은층의 정신건강 악화

예-2: 중국의 ASF(아프리카돼지열병) 팬주틱 바로 이어 COVID-19 팬데믹으로 악화

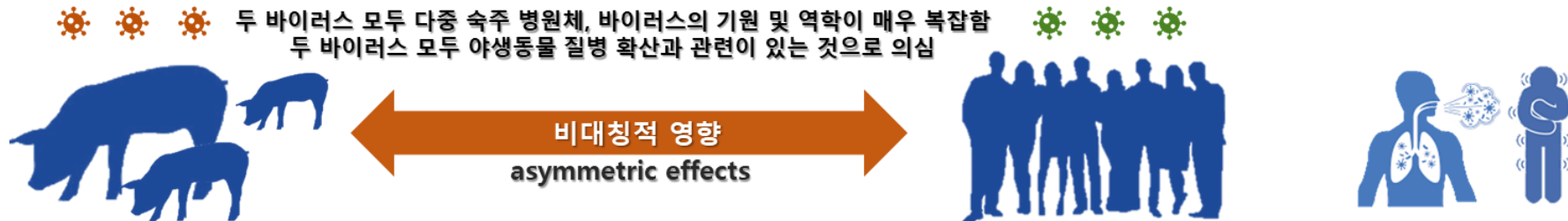
2018년 중국 양돈농가에서 ASF 보고 → 백신 없고 전염성 강해서 2019년 본격 팬주틱(Panzootic)

→ 동일 지역에서 COVID-19 출현(2019년 12월) → 2020년 COVID-19 본격 팬데믹(Pandemic)



ASFV(야생멧돼지 연관 추측)

SARS-CoV-2 (관박쥐 유래 추측)



비대칭적영향 가설: ASF로 돼지도살 → 돼지고기 부족, 다른 단백질 공급원 찾는 식단변화 발생 → 야생 동물 사육 의존도 증가 → 습하고 따뜻한 환경에서 유통
→ SARS-CoV-2 중간숙주(감염원)에 노출 증가

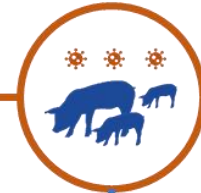
[출처] <https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2021.718546/full>

One Health

인간의 건강, 동물의 건강, 환경의 건강 사이의 상호 의존성에 바탕을 둔 개념

- 여러 전문가들이 협력하여 사람, 동물, 그리고 환경 모두에게 가장 좋은 건강 상태를 이루기 위해 지역적, 국가적, 그리고 전세계적으로 함께 노력
- 이는 사람, 동물, 환경이 서로 밀접하게 연결되어 있음을 인식하고, 이들 모두의 건강을 향상시키기 위해 다양한 분야에서 전문가들이 협력하는 것을 강조

ASFV: 인수공통 감염병이 아니지만 경제, 영양, 환경 관리, 무역, 식량안보, 야생동물 상호작용 등을 포함하여 인류 인구에 광범위한 영향을 미침



COVID-19: 인간건강 문제이며 항공여행, 소비동향, 환경영향 및 정신건강을 포함하여 전 세계 인간 삶의 거의 모든 측면에 영향을 미침

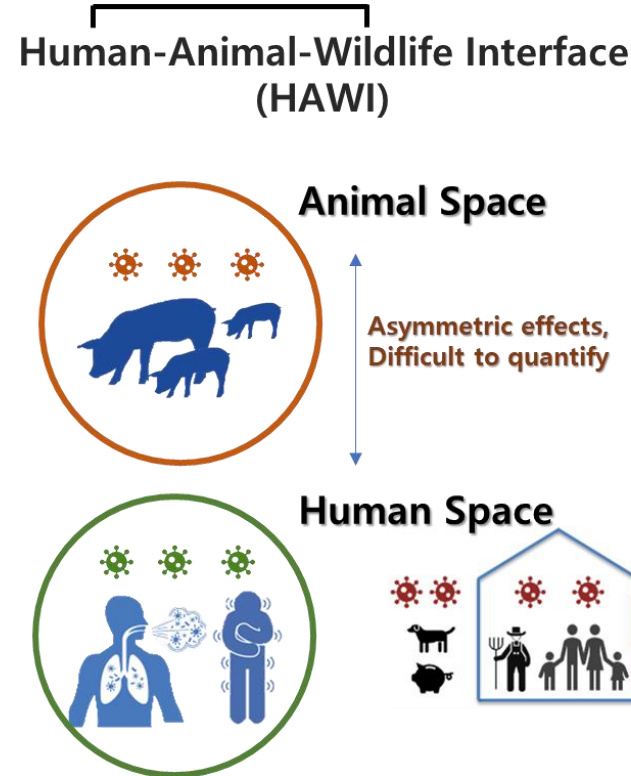
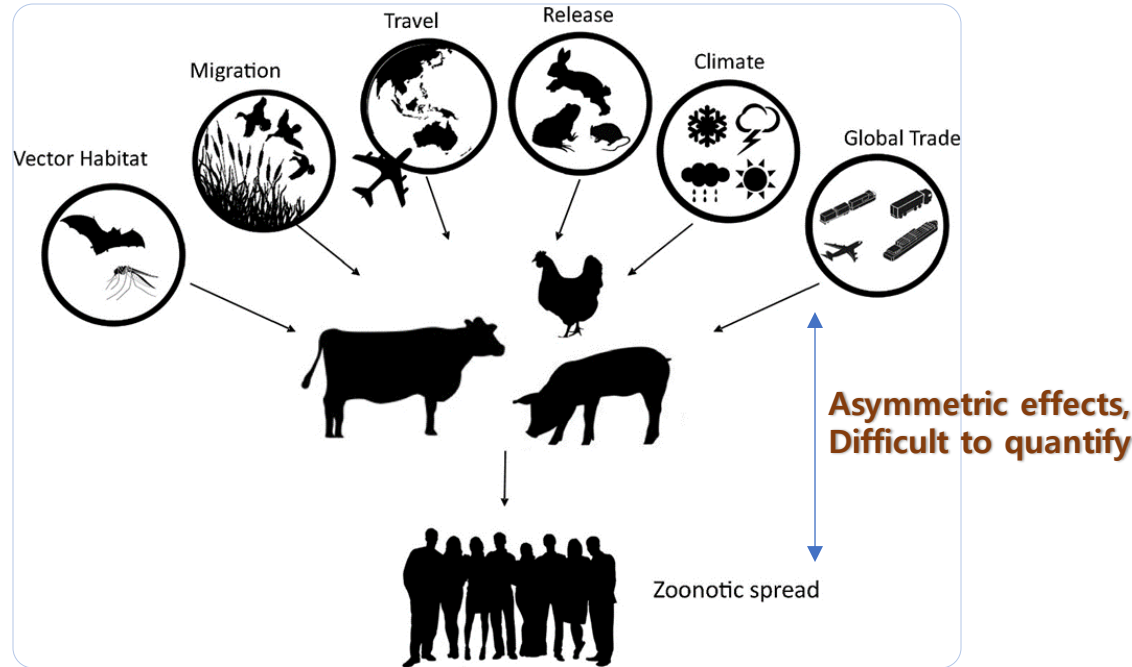


multidisciplinary approach

다방면적인 복잡한 문제를 협력적으로 해결하기 위해 다양한 학제간 전문가로 구성된 팀 **One Health 접근 방식**이 요구됨

How can a multidisciplinary approach be implemented?

Image Credit: Vaccine, Volume 35, Issue 44, 20 October 2017, Pages 5967-5973



The **MATLAB Toolbox** integrates various functions to support an ICT-based multidisciplinary approach. Utilizing this toolbox can foster collaboration within the academic culture.

How to put HAWI into a multidisciplinary approach?

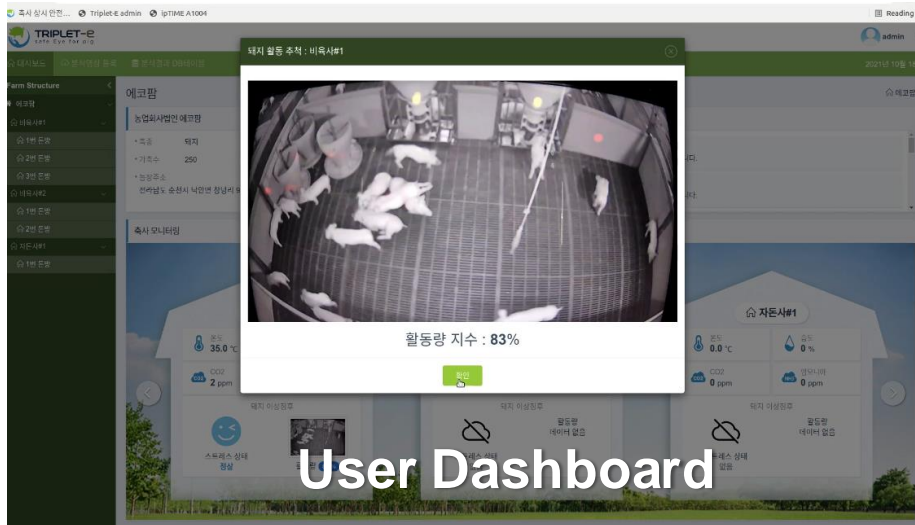
→ Area(or space) ICT-centric Approach based on NPI(Non-Pharmaceutical Intervention)

→ **Matlab Toolbox**

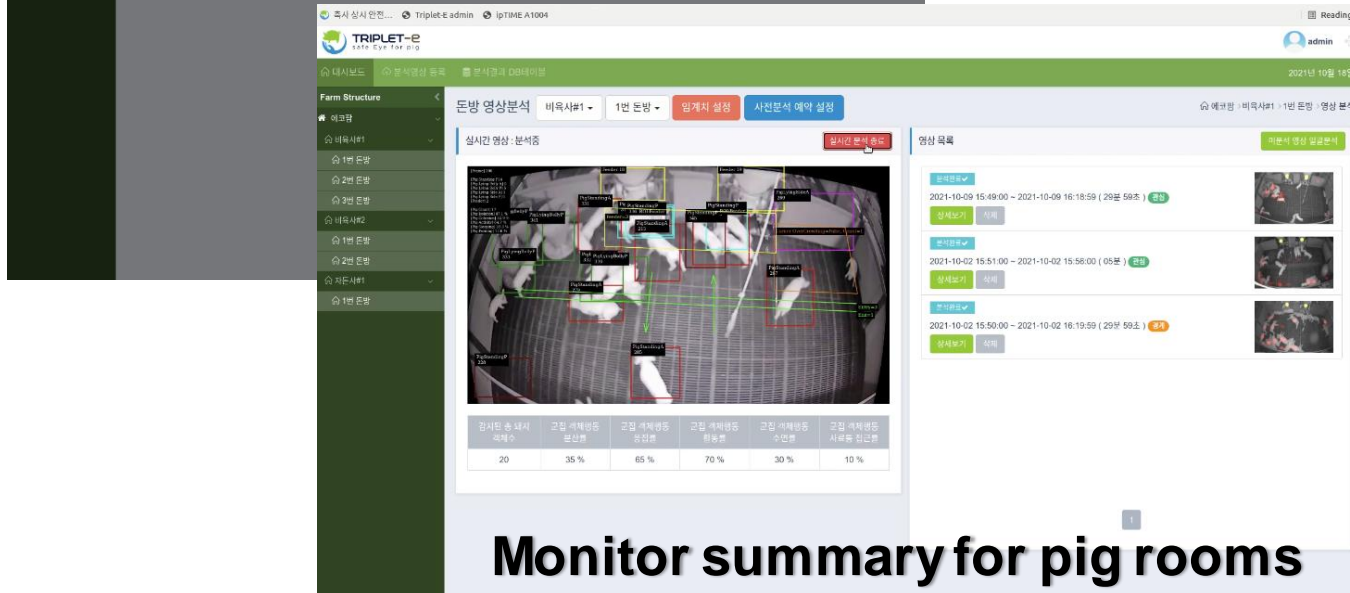
<https://kr.mathworks.com/products/alphabetical.html>

Topic 2: Anomaly Detection in Livestock

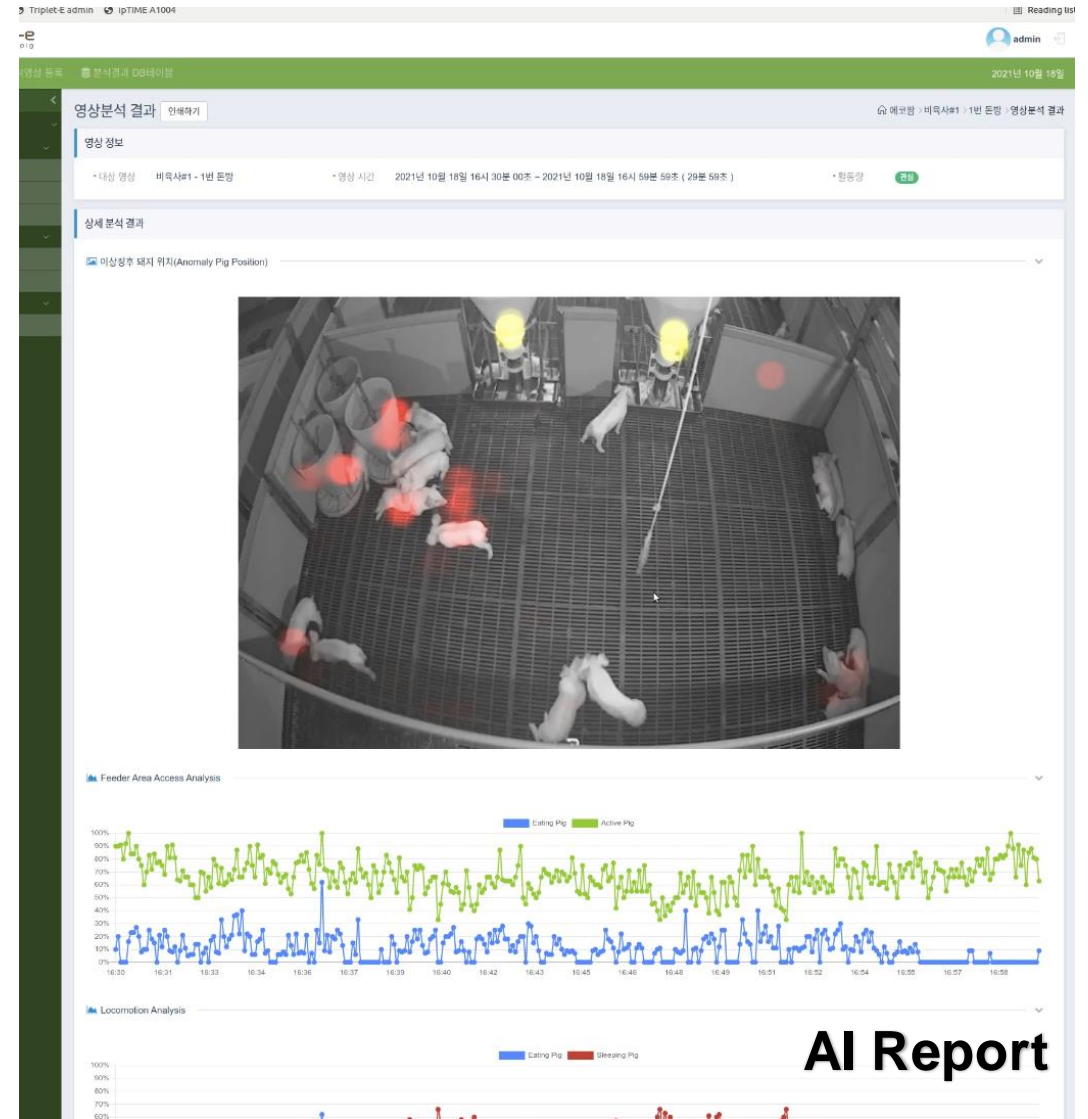
Triplet-E system: Web-based User Service with AI Report



User Dashboard



Monitor summary for pig rooms



AI Report

Criteria for Anomaly Detection Pigs using Surveillance Camera

영상카메라를 통한 이상징후 판단 기준 (Anomaly Detection Criteria observed by ETRI 정의)

1

Feeding & Drinking (Area access)

- 사료섭취행위
- 사료통(물통) 접근성(잘 먹는 아이는 건강)
- 배설지역 접근성(아픈 돼지는 자주 설사)

2

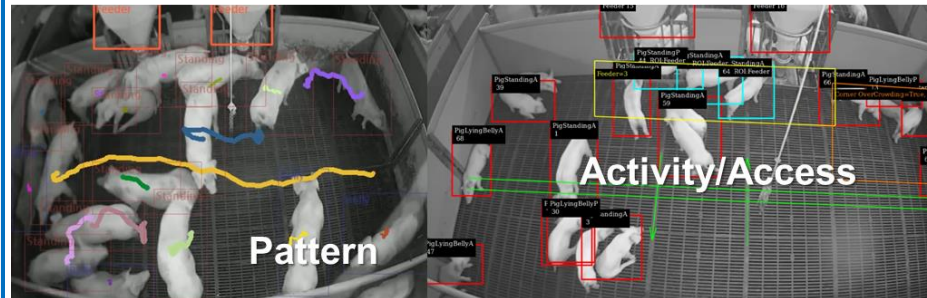
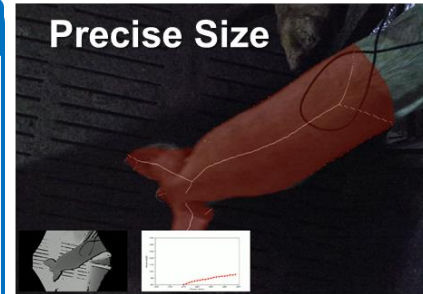
Posture and Locomotion (Activity)

- 건강한 아이는 잘 돌아 다님(Standing Posture)
- 외소하고 약한 아이는 비 활동적임
- 건강하게 잠자는 모습(Lying Side Posture)
- Change-in-Pattern (변화 패턴) :
 - ✓ Cohesion or isolation (응집력 또는 격리)
 - ✓ Group-pig Time-lapse pattern (Interaction with enrichment)

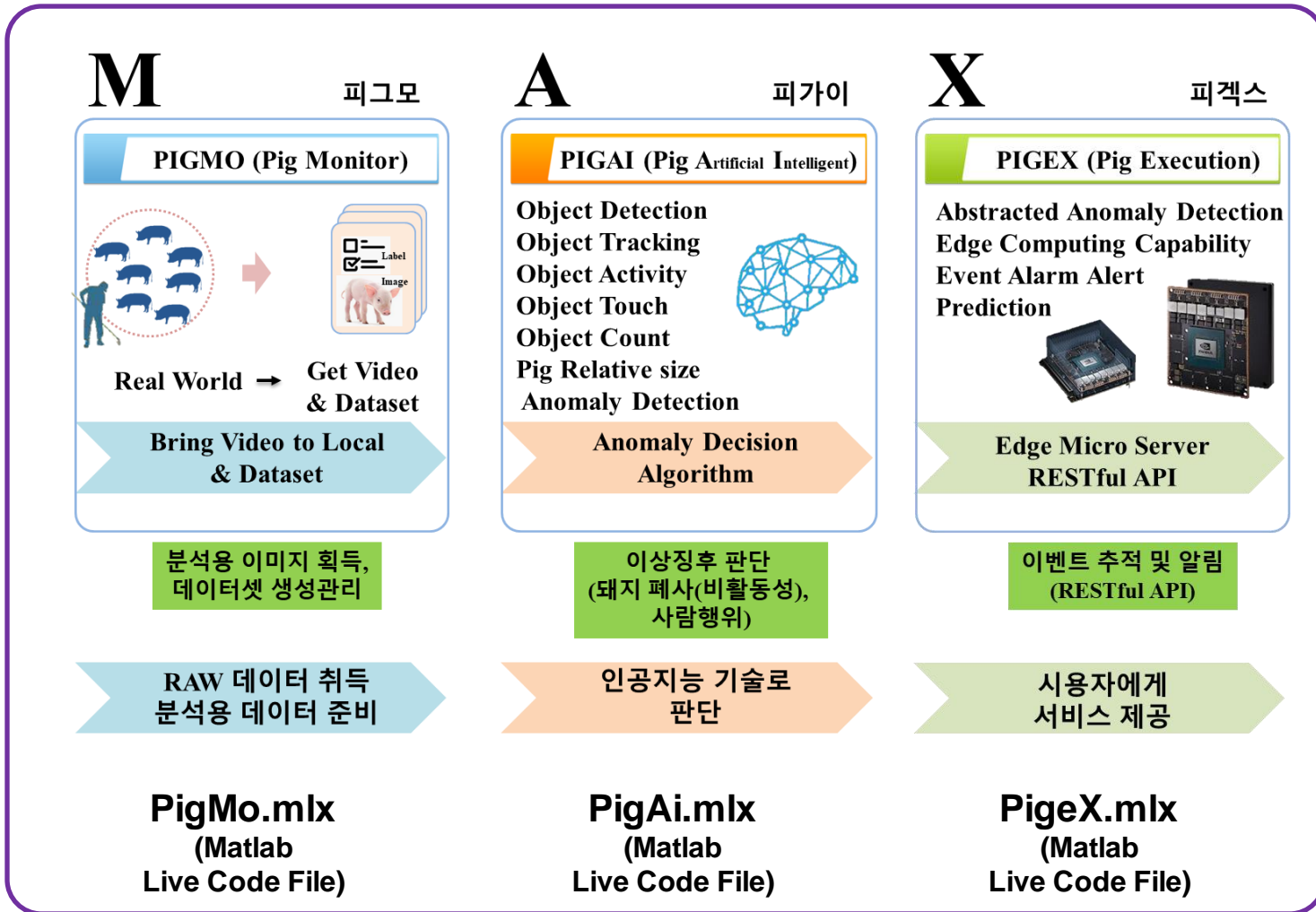
3

Relative vs Precise Size (Average Size)

- 약한 아이는 상대적으로 다소 외소함
- Undergrown(Min) vs Overgrown(Max) 차이존재



Matlab based MAX (PIGMO, PIGAI, PIGX) Workflow

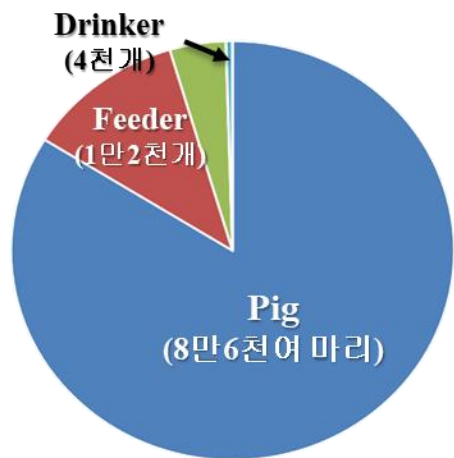


- Image Labeler for PIGMO
- Create PIGAI model
- GPU coder for PIGEX Edge

- Converted ONNX(PIGAI model) + C/Python Wrapper
- C/C++ Code for PIGEX for Edge system (Nano board)

Triplet-E system for Service Server **ETRI**

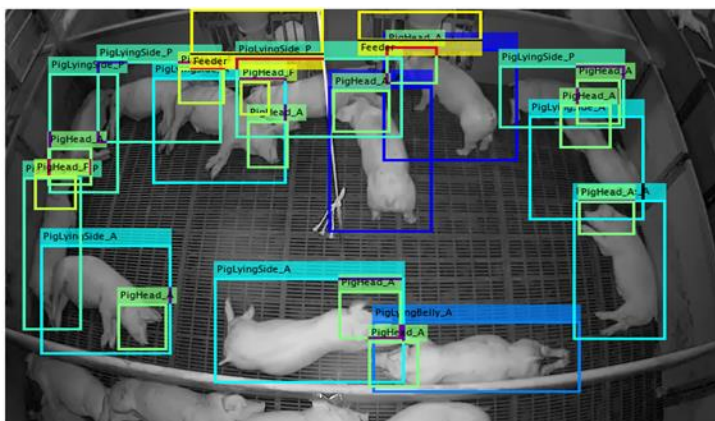
Pig Datasets using Image Labeler



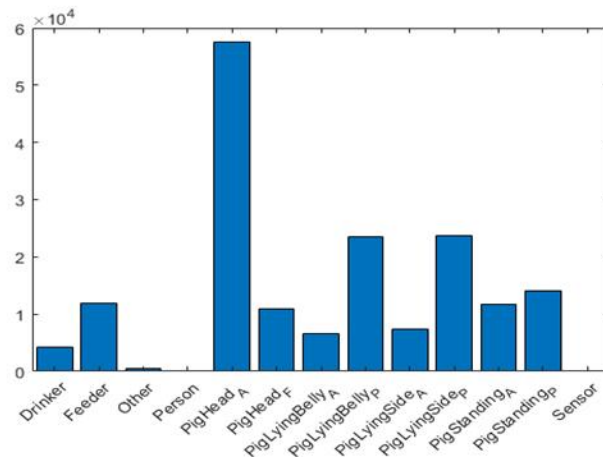
Ground Truth Bounding Box 개수 분포

ETRI 돼지 데이터셋 개발 개요

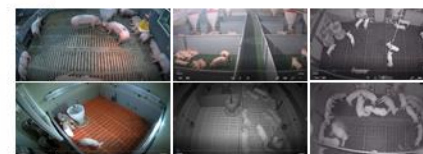
- 돼지 축사 사진 (Raw Images) : 6,014 장
- 분류 클래스(Class) : 13 개
- 라벨링 된 객체 총 개수 : 172,275 개 (17만개)
- 라벨링 된 돼지의 총 객체 수 : 86,965 마리
- 데이터셋 기능
 - 돼지 자세 : 3종 자세 구분(서있음, 누움, 옆드림)
 - 돼지 응집 여부 : 붙어져 있는지, 떨어져 있는지 구분
 - 돼지 행동 방향 : 돼지 행동 방향성 (돼지 머리 라벨링)
 - 객체 종류 구분 : 5종(돼지, 먹이통, 물통, 센서, 사람)



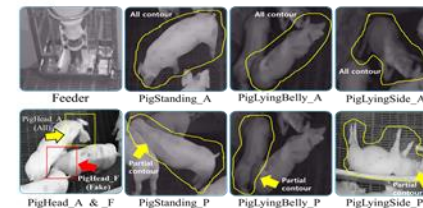
Ground Truth Bounding Box 라벨링 예



클래스별 Ground Truth Box 개수 분포



3개 농장, 6개 돈방에서 영상획득



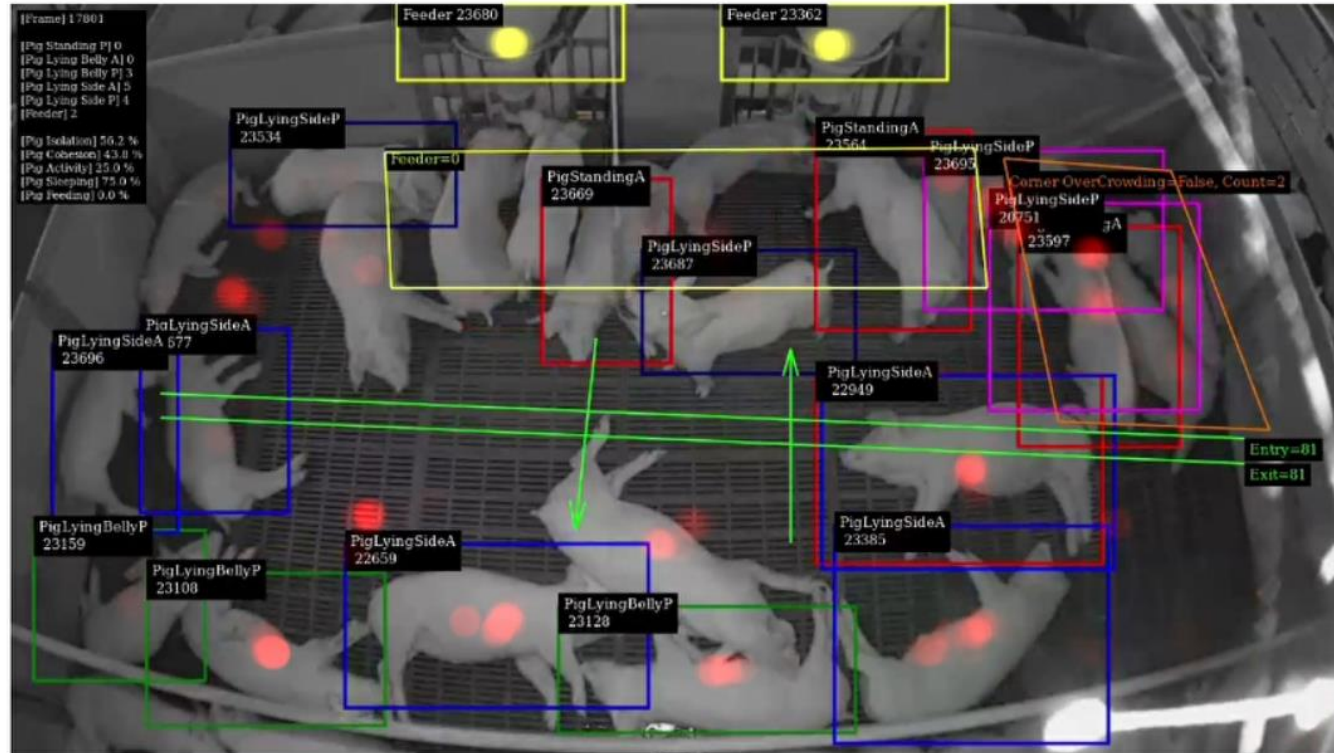
돼지 자세 및 응집 여부 구분

Q) How to train workers to label pig images?

A) YouTube!
(There is no additional charge for training.)

Once completing the creation of the pig datasets, the label information can be generated as a CSV file from an MLX script and then shared with Python users.

Triplet-E (Safe Eye for Pig) system



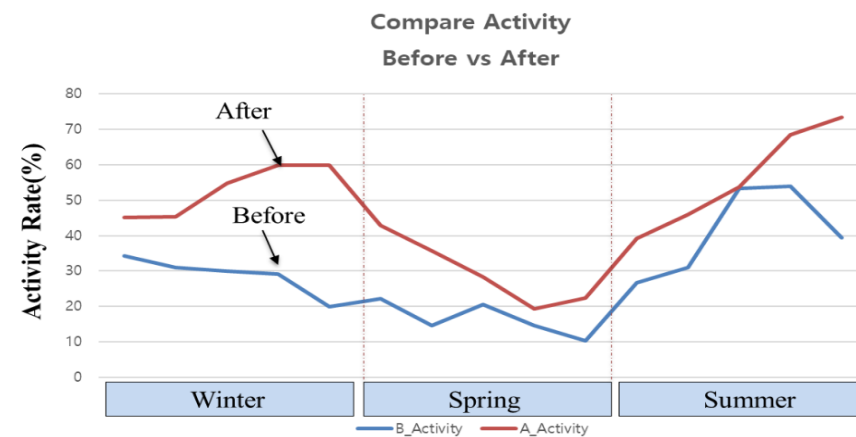
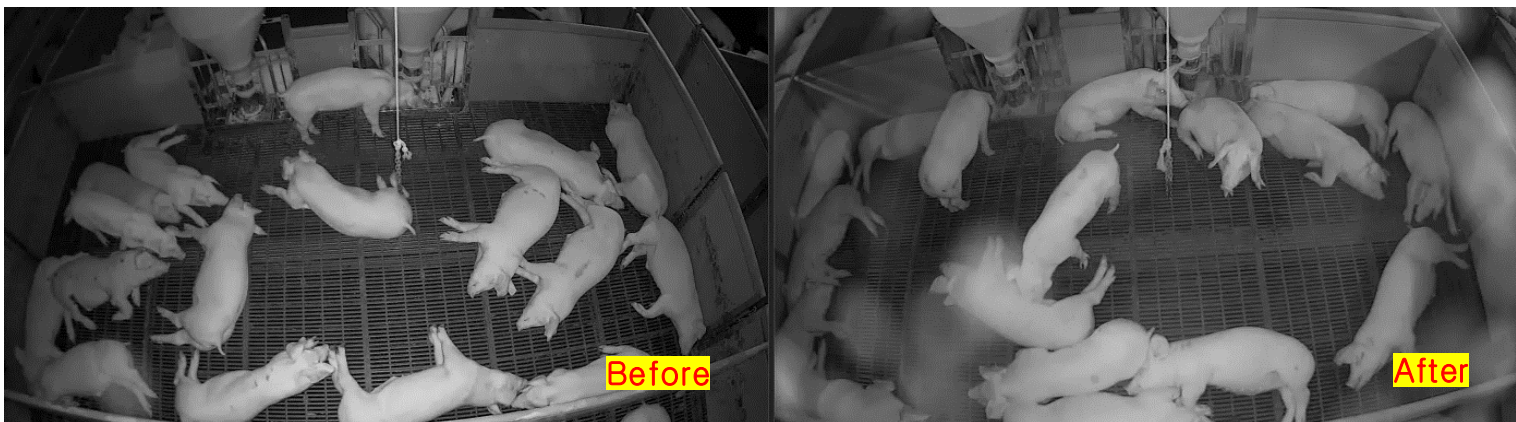
📊 통계 데이터(Statistical Information)

군집 객체행동 분산률	군집 객체행동 응집률	군집 객체행동 활동률	군집 객체행동 수면률	군집 객체행동 사료통 접근률	군집 객체행동 활동상태
55.6 %	43.6 %	28.6 %	70.6 %	8.3 %	관심 (28.6)

Play Video Clip

Triplet-E system AI generates Pig's daily Life Report

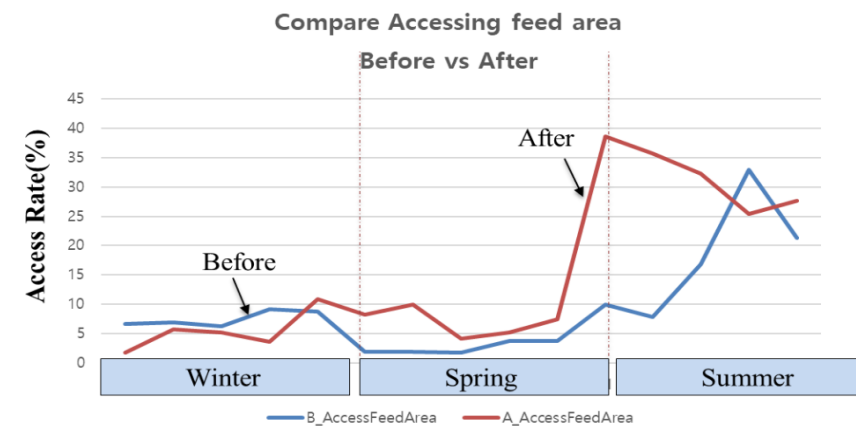
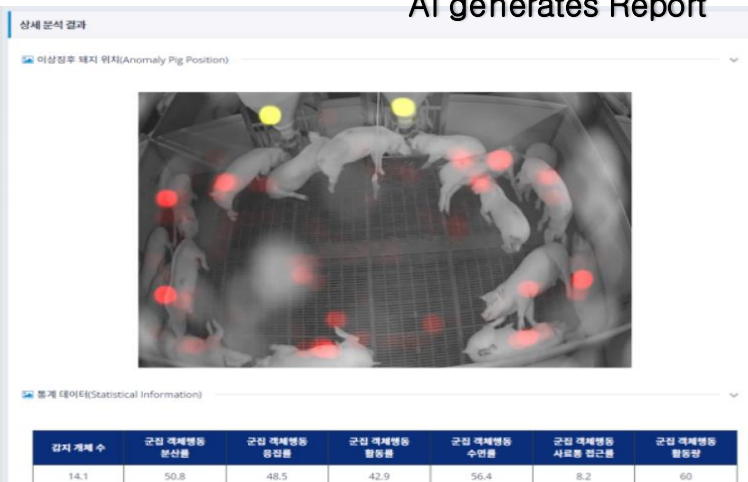
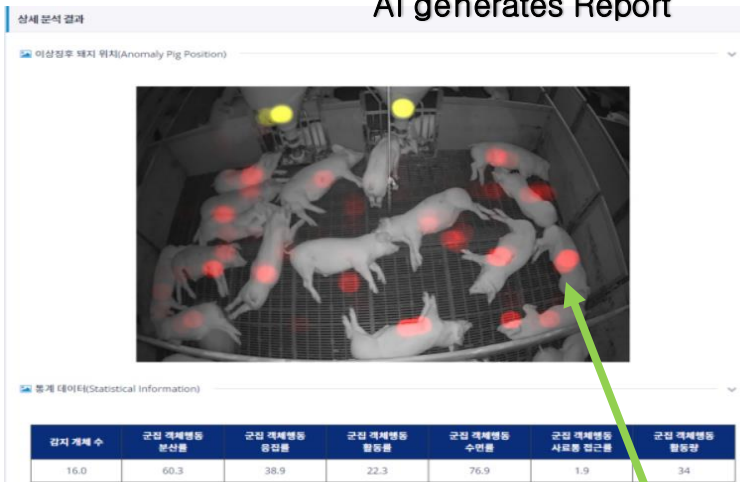
Before vs After air purification system installed



AI generates Report



AI generates Report



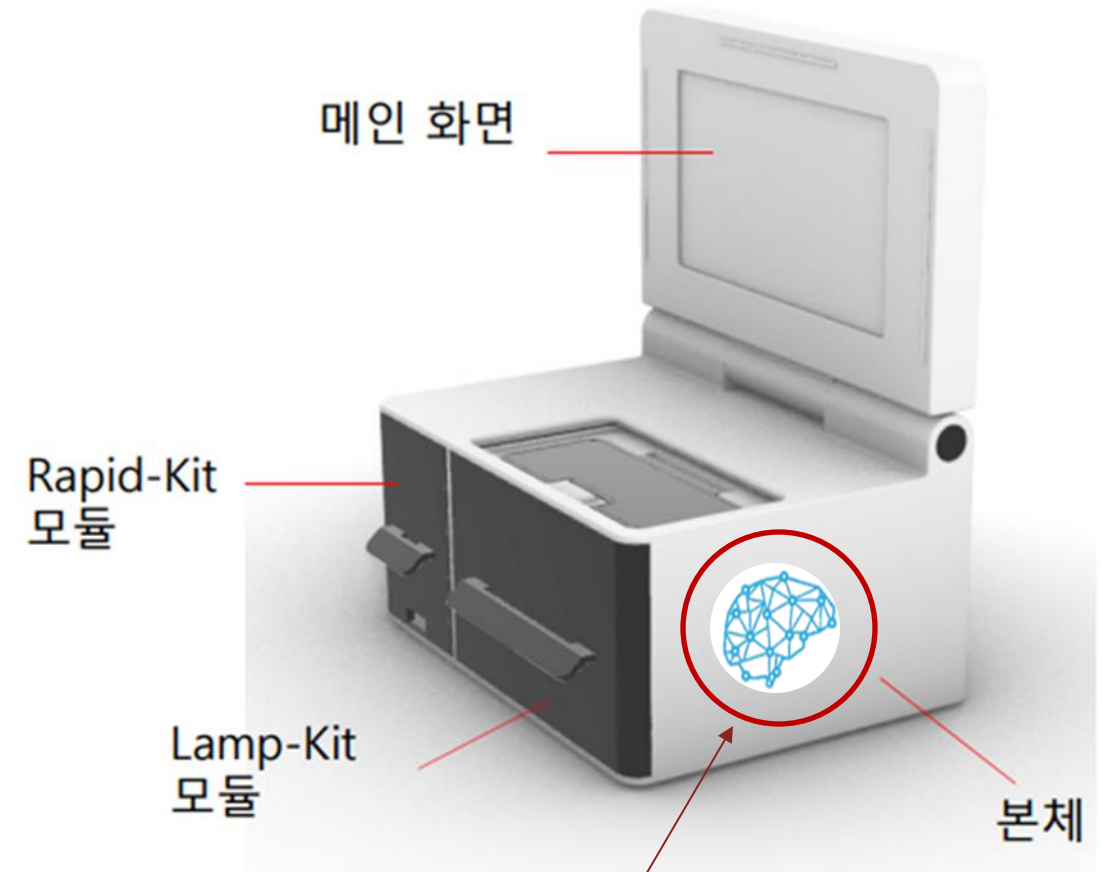
The darker the shade of pink, the more likely it is to be an anomaly pig.

Topic 3: Predicting Antigen Concentration in Rapid Kits

One system integrated by LFIA and PCR

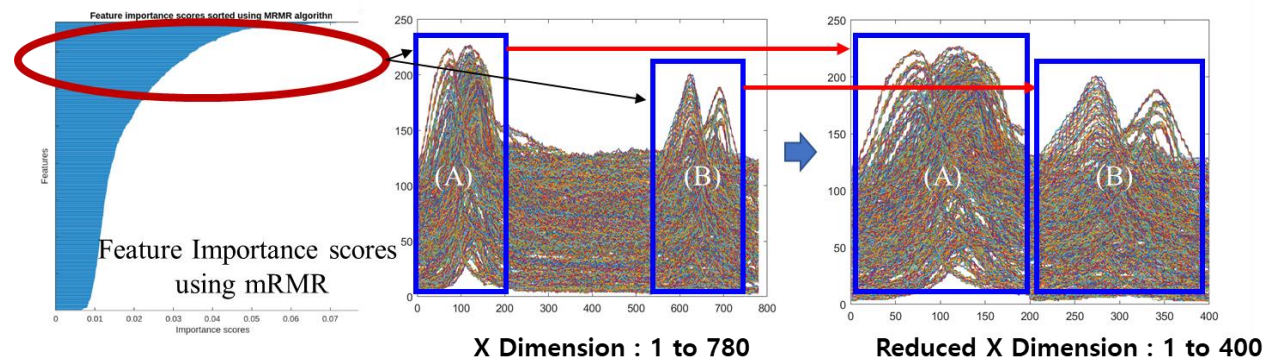
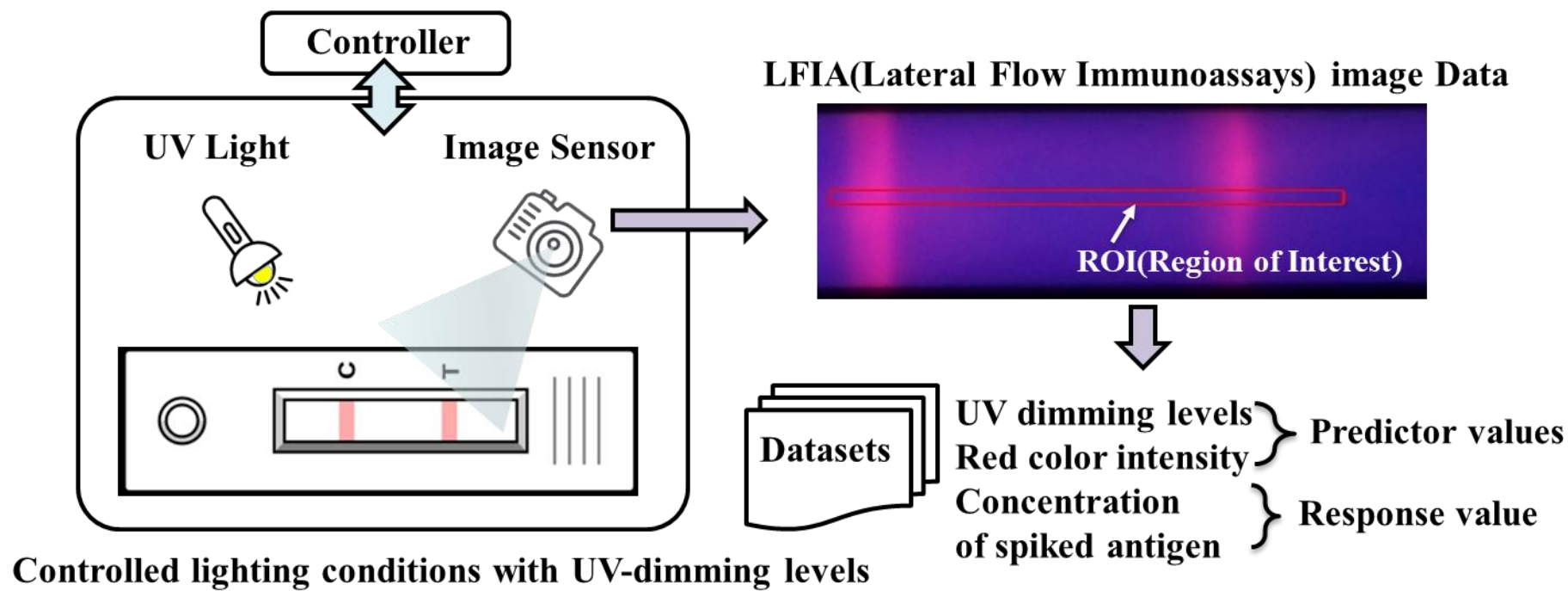
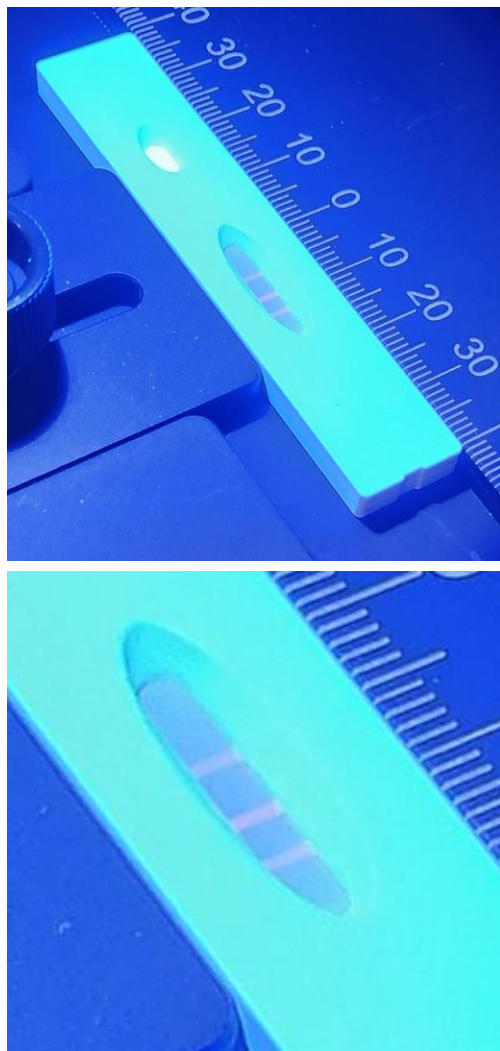


LFIA (Lateral Flow ImmunoAssay) : RAPID-KIT
PCR (Polymerase Chain Reaction) : LAMP-KIT

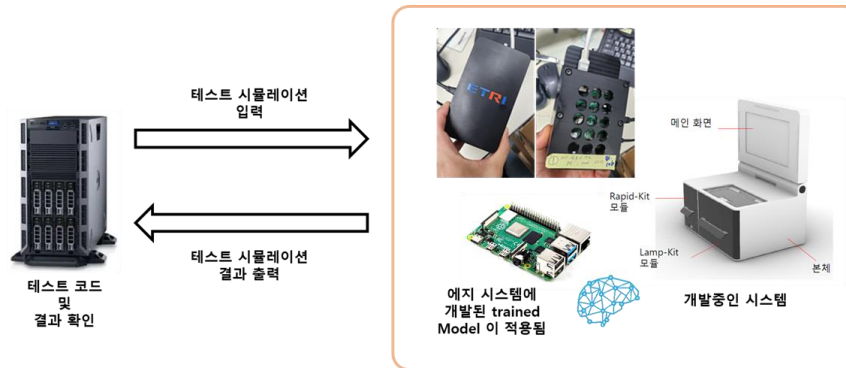
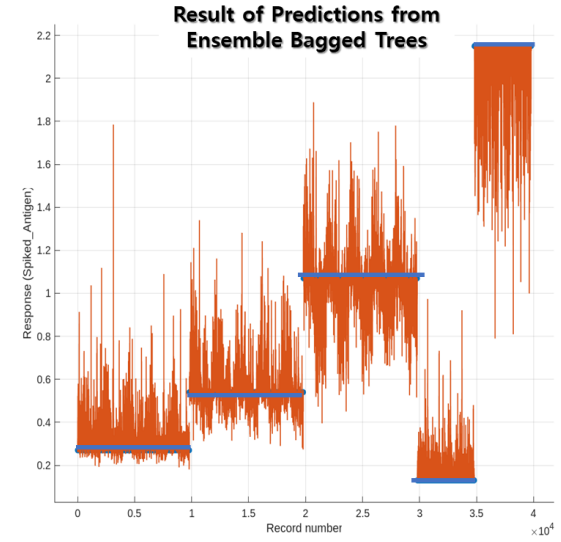
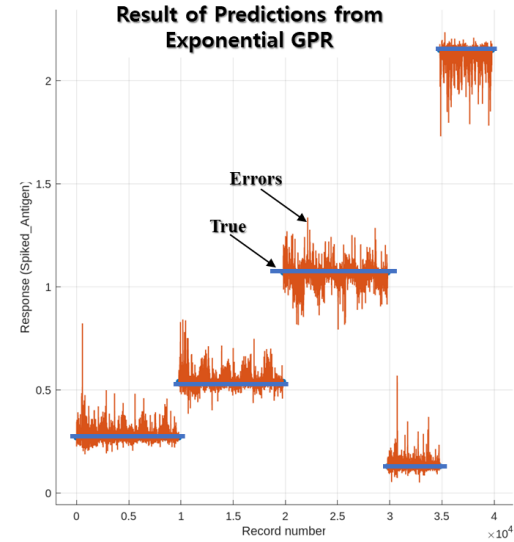
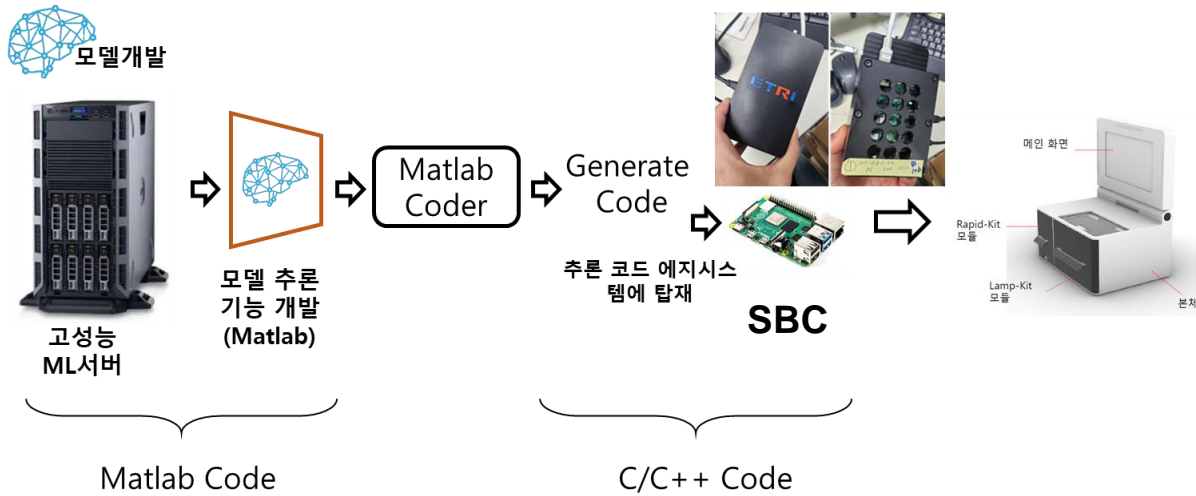


Single Board Computer is built into the system

LFIA Datasets



Matlab ML, Coder, SW PIL(Processor-in-the-Loop) Test Workflow



SW PIL Test

동일함

```

Test_Observers= 75001 :: [MexPrediction value : 0.103705 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.103705 ]
Test_Observers= 75003 :: [MexPrediction value : 0.107291 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.107291 ]
Test_Observers= 75006 :: [MexPrediction value : 0.127117 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.127117 ]
Test_Observers= 75010 :: [MexPrediction value : 0.140167 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.140167 ]
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Test_Observers= 75021 :: [MexPrediction value : 0.122741 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.122741 ]
Test_Observers= 75028 :: [MexPrediction value : 0.120817 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.120817 ]
Test_Observers= 75036 :: [MexPrediction value : 0.123485 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.123485 ]
Test_Observers= 75045 :: [MexPrediction value : 0.126336 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.126336 ]
Test_Observers= 75055 :: [MexPrediction value : 0.126694 ] vs [Label value : 0.130000 ] vs [PilPrediction value : 0.126694 ]
    
```

Conclusion

- The pandemic highlighted the importance of One Health and the need for integrated, multidisciplinary tools. MATLAB is an excellent tool for scientific collaboration.
- Triplet-E, using models created in MATLAB, empirically improves pig farm management by more than 15%.
- Thanks to MATLAB's ability to generate C/C++ code and seamlessly integrate systems, Rapid Kit diagnostic devices greatly aid in the swift prevention of infectious diseases.

MATLAB EXPO



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