

# Pilot Study of Inspection of Hydraulic and Slope Stabilizing Structures by Using UAV and High-Resolution Thermal Imaging



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# Outline





# Purposes

Enhance management  
and operation  
capabilities

## Objectives

- ✓ Undergoing **non-destructive inspection** to **hydraulic and slope stabilizing structures** by UAV with **thermal camera**.
- ✓ **Rapid** inspection, working **safety** and high **accuracy**
- ✓ Determination of **weariness and structural damage** with new technologies, **enhance the UAV applications** and **reduce manual inspections**.

## Problems to be solved

- ✓ Inspection of **remote** (not-easy-to-reach) **concrete structures** by UAV with **RGB and thermography camera**.
- ✓ Try to **apply AI training** for structure defects detection using thermal images.



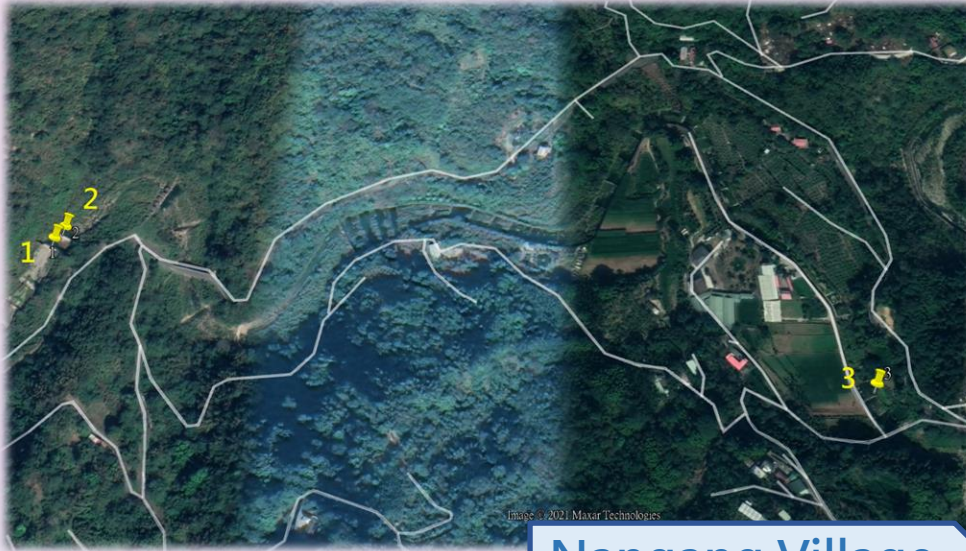
# Study Areas

## Target study areas

Location : Mountain areas in Nantou County.

Target objects : Hydraulic and slope stabilizing structures near streams

➡ concrete structures like **embankment**, **retaining walls** and **box culverts**



Nangang Village



Tannan Village

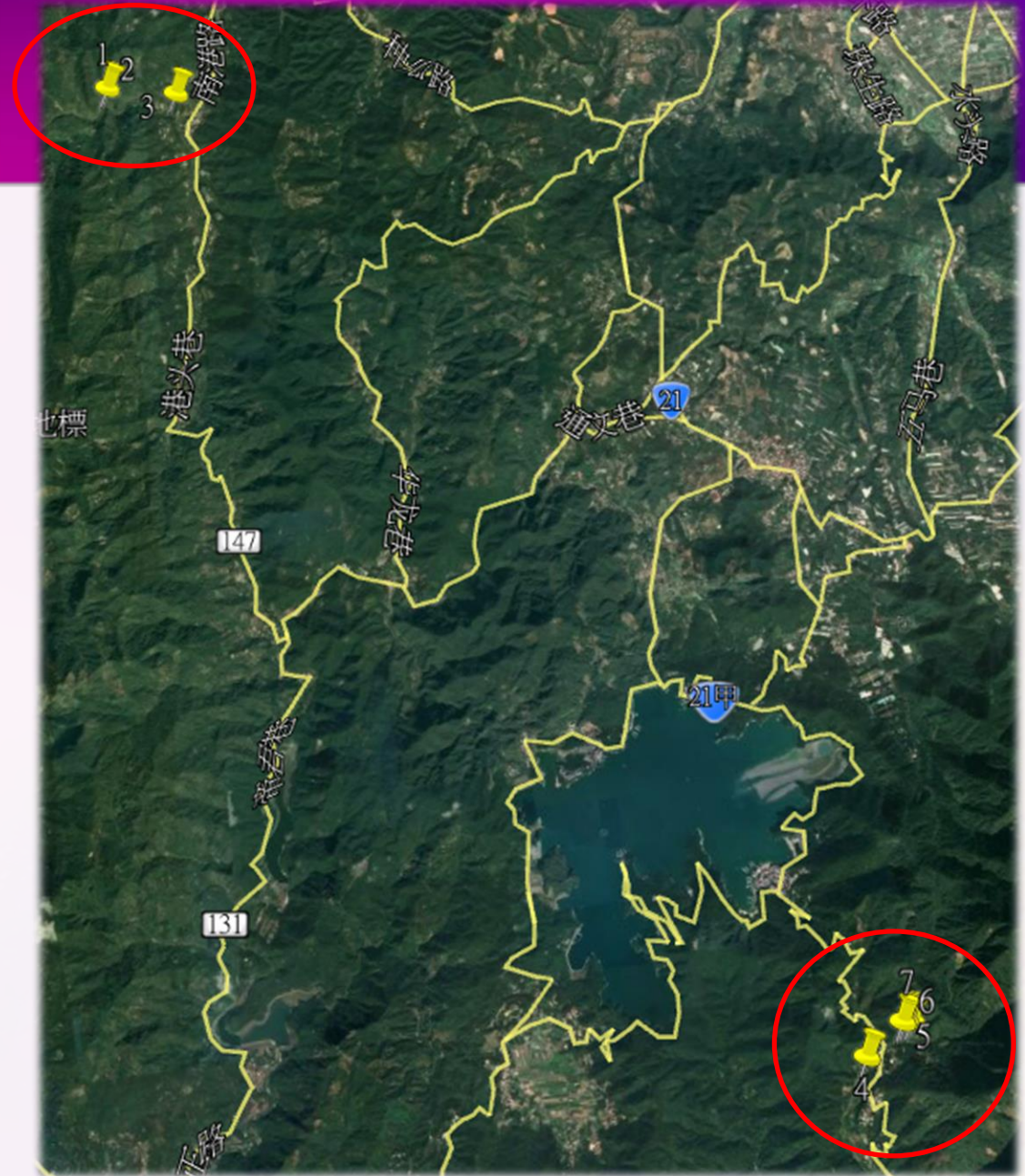


# Study Areas



7 locations were chosen for study in the initial stage

No.	Location	Coordinates
1	Nangang	23°57'03.3"N 120°51'17.4"E
2	Nangang	23°57'03.8"N 120°51'19.3"E
3	Nangang	23°57'01.6"N 120°51'54.1"E
4	Tannan	23°49'28.1"N 120°56'19.4"E
5	Tannan	23°49'40.6"N 120°56'41.3"E
6	Tannan	23°49'40.4"N 120°56'41.9"E
7	Tannan	23°49'40.1"N 120°56'43.0"E

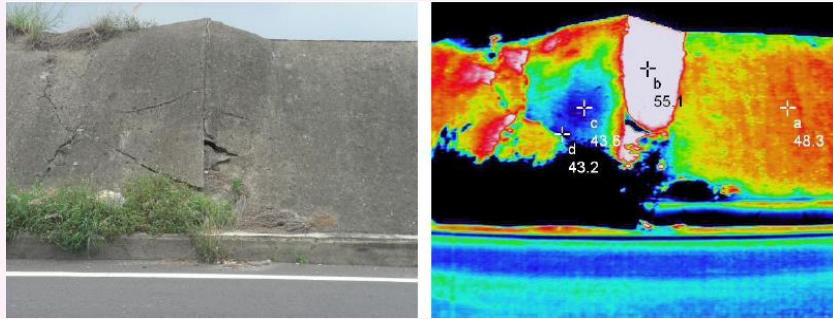




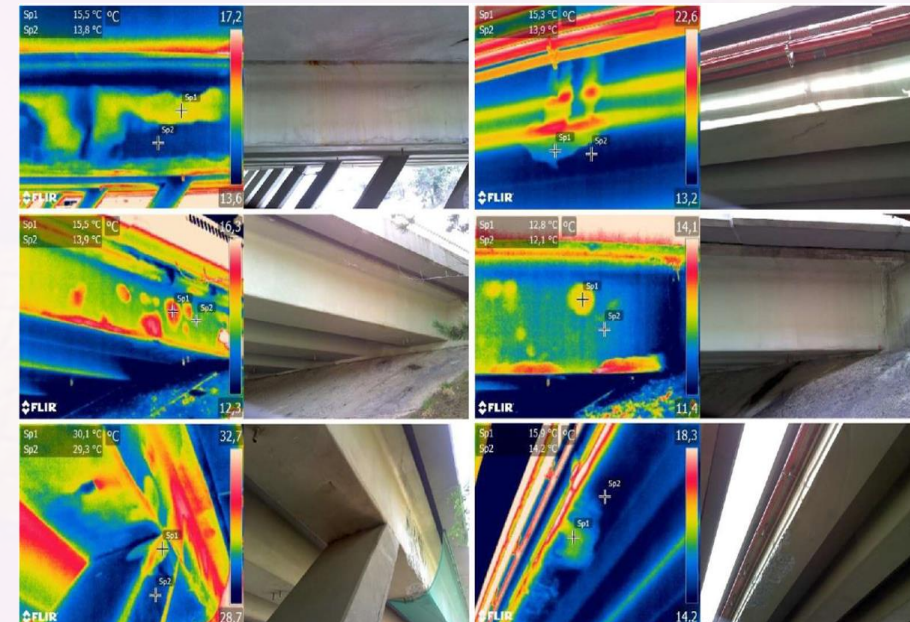
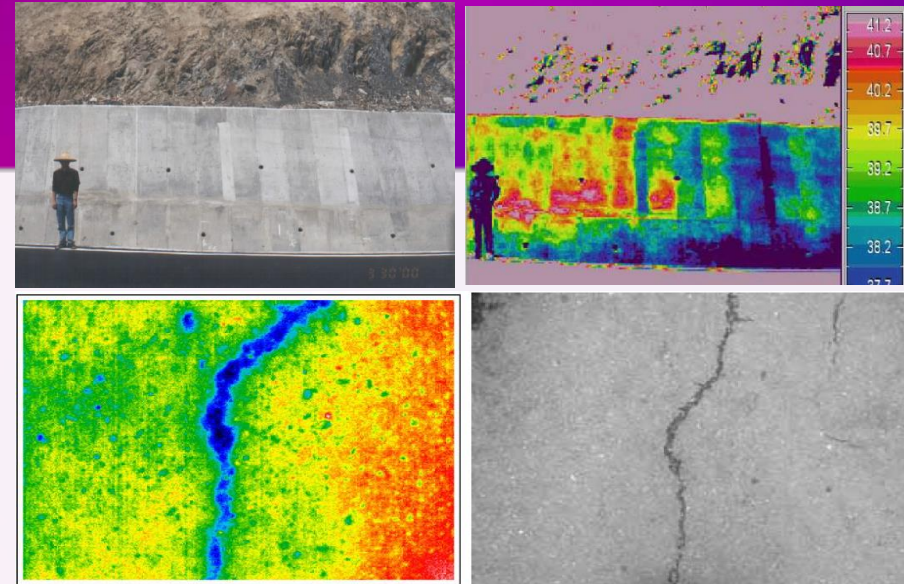
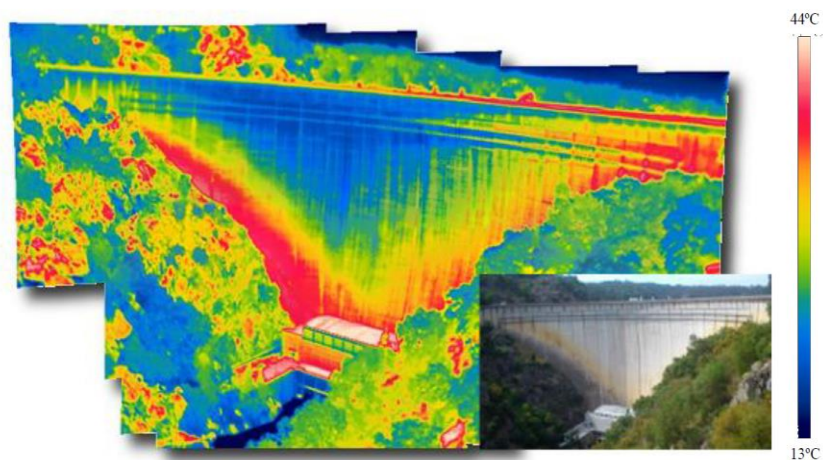
# Literature Review



Lots of studies show the efficient and possibilities of cracks and internal damages detection by using thermal cameras.



Maria João Henriques and Pedro Ramos





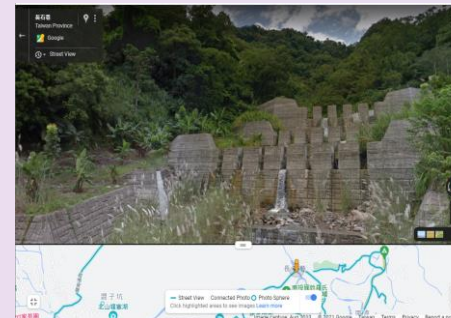
# Sampling Procedure



## Locations

- ✓ Vegetation cover
- ✓ Obstacles
- ✓ Terrain and signal reception

1	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
2	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
3	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
4	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
5	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
6	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
7	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
8	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
9	101-101-101-101	Station Name	Station Type	Station Category	Station Sub-category	Station Address	Station Coordinates	Station Elevation	Station Photo	Station Description
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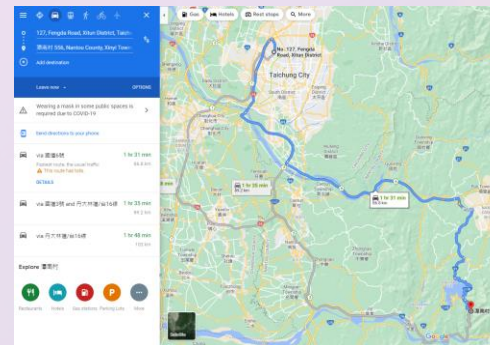
Documents

Google Earth

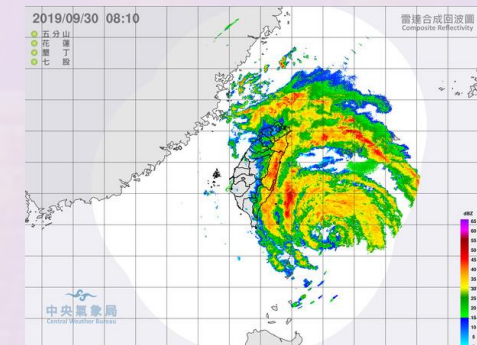
On-site inspection

## Preliminary study

- ✓ Determine the appropriate and possible locations
- ✓ Suitable weather: wind claim, no participation and clear day



Locations and maps



Weather forecast



# Sampling Procedure




# UAV Permission

- No Fly Zone**  
**Restricted Area**  
**Permitted Area**  
**National Parks**

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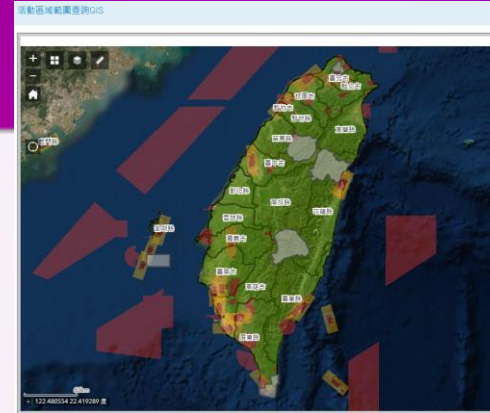
# UAV Flight Paths

-  **Decided the suitable UAV flying paths**

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## On-site Operation

-  **Taking images at planned locations**



附件 2				
墾丁國家公園操作遊控無人機申請書(範例)				
申請人名稱	王小明	操作人名稱	王小明、王大明	
		觀察人名稱	王小明、王大明	
現址地址	臺東縣延平鄉延平村 596 號			
現址建物坪數	王小明	連絡手機(電話)	0970121215	
拍攝空域	深空拍攝計畫	起飛地點時間	上午 9 點開始	
(拍攝區域標名)		降落地點時間	下午 3 點結束	
拍攝日期	自 109 年 8 月 10 日	至 109 年 8 月 15 日	共計 6 天	
航線及攝影、飛控、空域	機型、機牌號碼如下：			
空域計畫	拍攝地點說明如下：			
(拍攝區域標名、機牌、機型、飛行高度、攝影)	小沙嘴沙灘、龍潭吊橋、龍潭吊橋公園、龍潭公園、風吹沙、水鏡潭、溪洲沙灘、龍潭吊橋、龍潭吊橋風景區、(上述地點均屬禁飛區)			
	空域計畫：			
	家庭前庭式無人機飛空拍攝計畫，於空域拍攝地點，不影響其他地區民眾、王大明高度 10 公尺，不超過 100 公尺的範圍時，王小明、王大明為操作人，觀察人由空管署指定空管員取得授權。			
<p>本申請人已詳閱空域及國家公園操作遊控無人機申請辦法及國家公園巡迴相關規定，如有違反，願負一切法律責任。</p>				
申請人簽名	操作人簽名		觀察人簽名	
	王大明		王大明	
中 華 民 國 109 年 8 月 7 日				





# Sampling Procedure

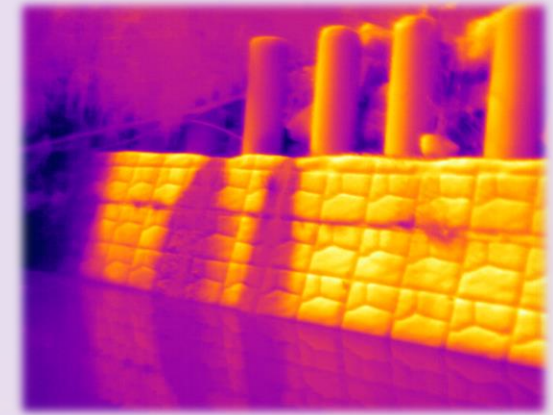
6

## Image Processing

- ✓ Import images and processing
- ✓ Separate RGB & thermal images from raw RJPG format



RGB Image



Thermal Image

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## Analysis

- ✓ Analyze the recorded structural damages

RGB Camera



Thermography Camera:  
capturing the surface  
temperature difference

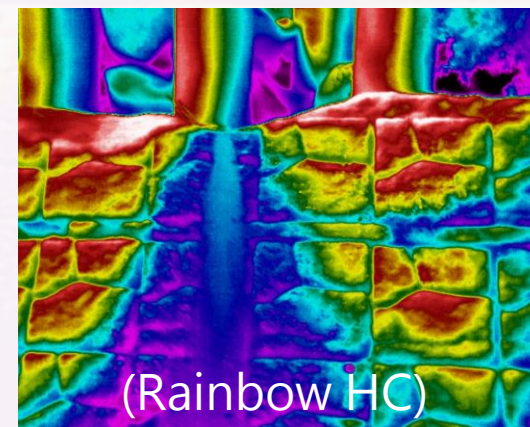
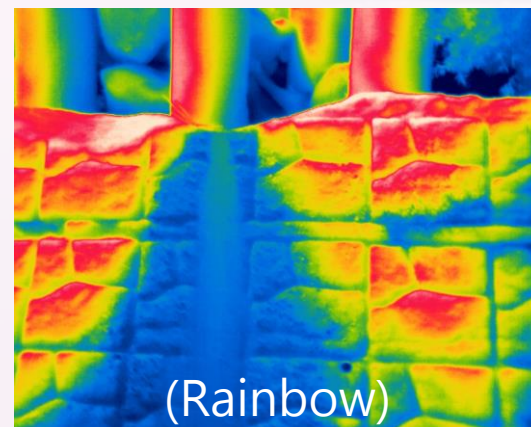
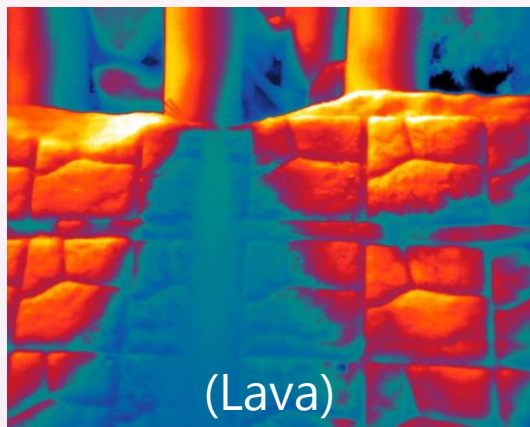
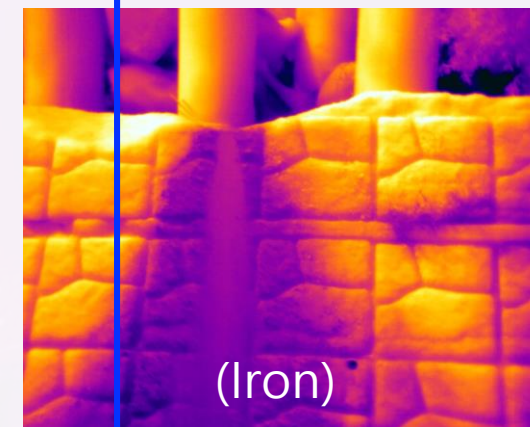
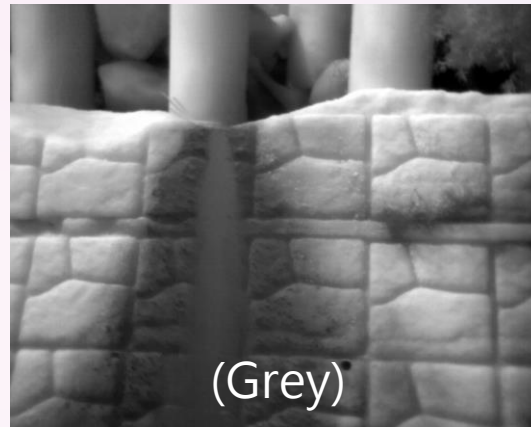
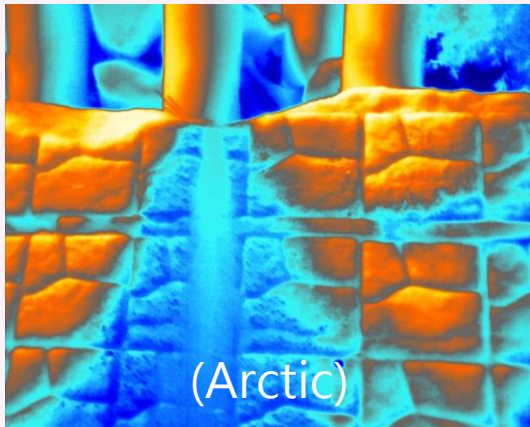


# Image Processing

- 🔍 Raw File displayed as Greyscale
- 🔍 Temperature embedded in every pixel
- 🔍 Importing Greyscale into FLIR TOOL
- 🔍 Rendering based on temperature variation



<https://www.flir.asia/>





# Test Run and Results

- 7 missions in 2 townships
  - ✓ Nangang Village (2021/02/22)
  - ✓ Tannan Village (2021/03/31)
- Flying altitude at 10 meters
- Manual control due to tiny maneuvering space and demanding wind situation
- On-site job :
  - 🌀 UAV controller – UAV and camera control
  - 🌀 Observer – observing obstacle and situations for the controller
  - 🌀 Assistant – equipment & vehicles management

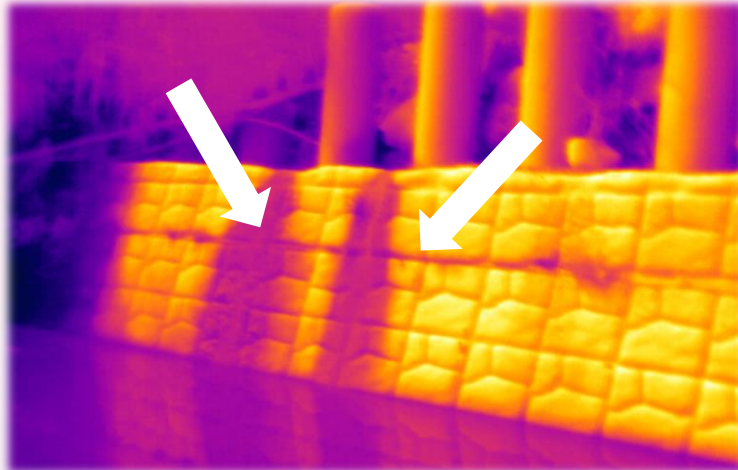




# Test Run and Results

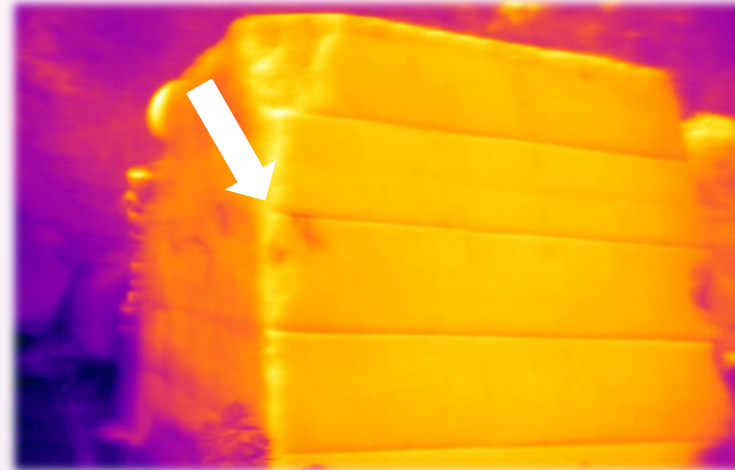
Nanyang Village 120°51'17.4"E 23°57'03.3"N

Location 1



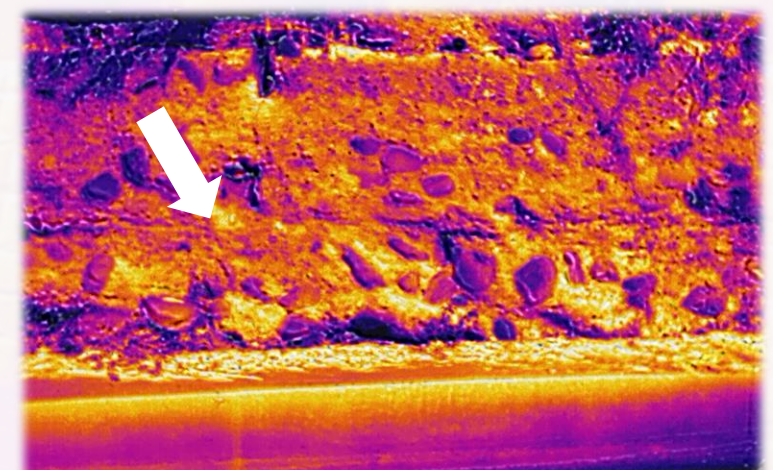
Nanyang Village 120°51'19.3"E 23°57'03.8"N

Location 2



Nanyang Village 120°51'54.1"E 23°57'01.6"N

Location 3

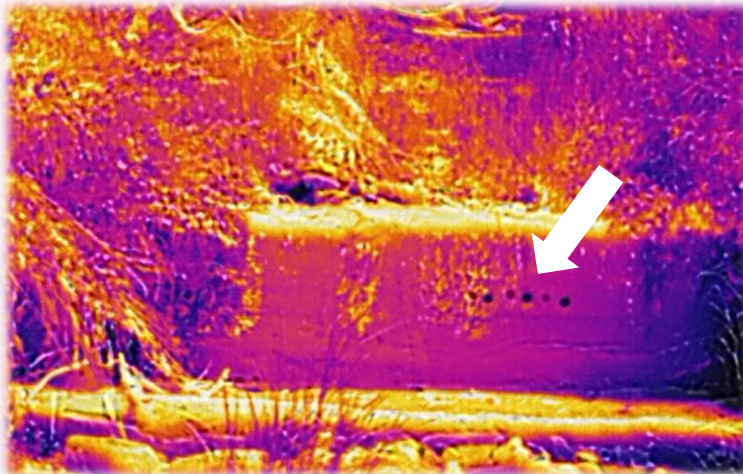




# Test Run and Results

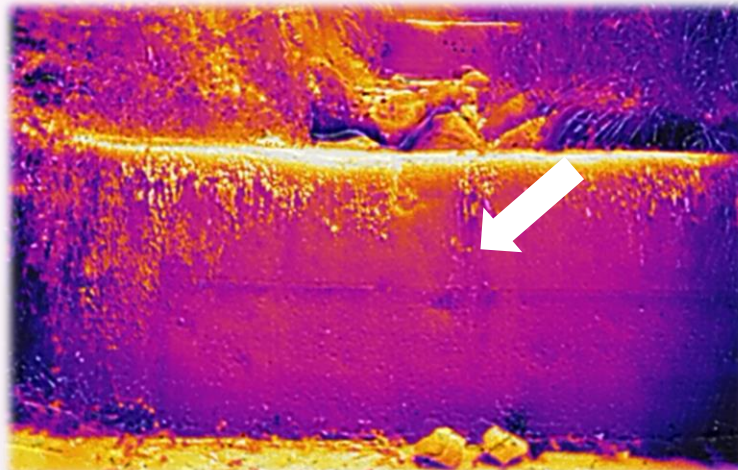
Tannan Village 120°56'41.3"E 23°49'40.6"N

Location 5



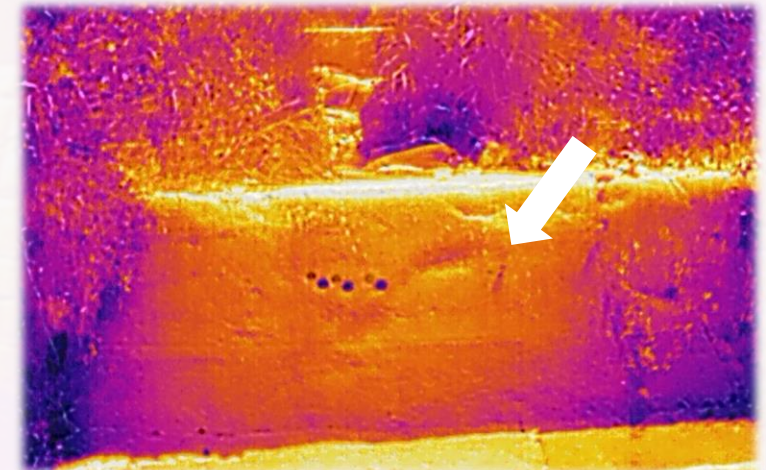
Tannan Village 120°56'41.9"E 23°49'40.4"N

Location 6



Tannan Village 120°56'43.0"E 23°49'40.1"N

Location 7





# Test Run and Results

Structural Damage Inspection – Slit Dam in Tannan Village as the example



Comparison of RGB & Thermal Images

Irregular linear patterns in 1 & 2

➡ suspected cracks

Irregular shapes and linear pattern  
in 3 & 4

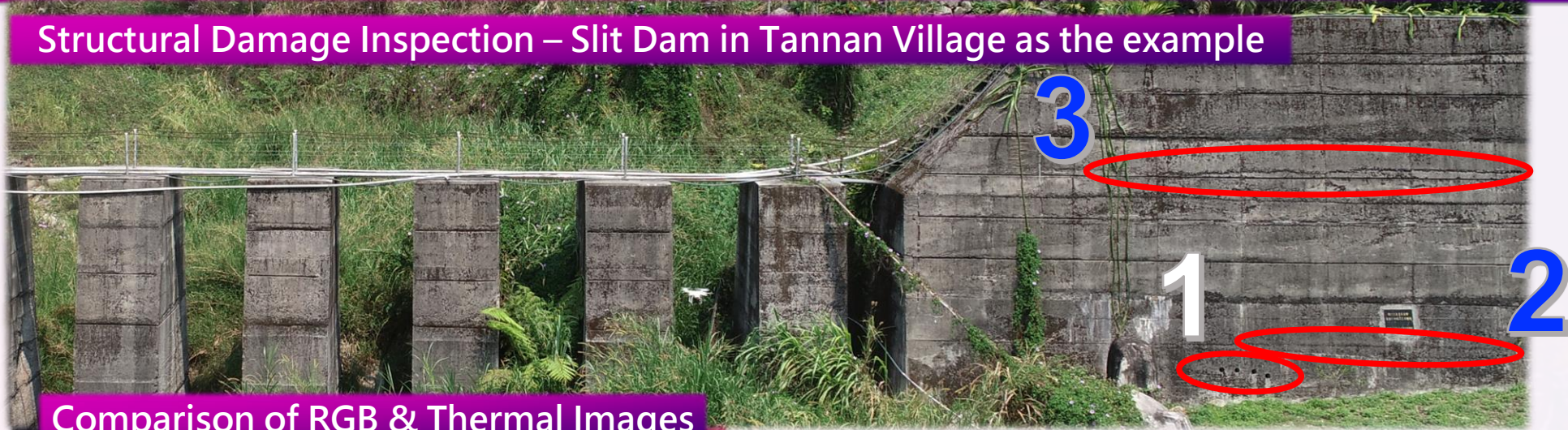
➡ possible defects of RC





# Test Run and Results

Structural Damage Inspection – Slit Dam in Tannan Village as the example



Comparison of RGB & Thermal Images



- Dark circular patterns in 1  
➡ **Confirmed** as coring holes (for testing)
- Irregular linear patterns in 2 & 3  
➡ **suspected** cracks



# Conclusions

- **Thermal images can potentially capture the defects, holes and suspected cracks on the surfaces of hydraulic RC structures.**
- **Through the comparison of thermal and RGB images, potential locations of cracks can be seen from the irregular linear patterns.**
- **Concrete defects can be found when darker patterns appear in the bright regions of the thermal images.**



# Next Steps

- In the initial study stage, the structure inspection using UAV and thermography camera is possible.
- Further investigations will be carried out in more regions, and the influence of light conditions (e.g., daytime and sunset) will be taken into consideration.
- To establish thermal image database for later **AI** training and identification.



# **Thank you for Listening**

Any questions? Contact [yimhuang@fcu.edu.tw](mailto:yimhuang@fcu.edu.tw)