インフラマネジメント技術国際展開研究助成・中間報告会

ケニアにおける橋梁維持管理のための UAVとAI損傷認識の実装

• Ji Dang
• Saitama University

JICA Bridge Management System Project, Bridge Inspection & Database SWG 2021

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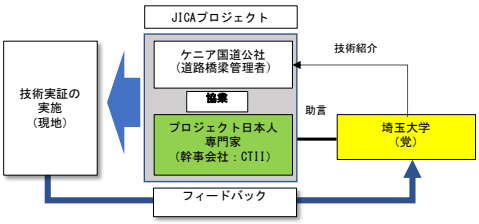
研究目的

• ケニア国 橋梁維持管理能力強化プロジェクト



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全体スケジュール

① 本プロジェクトは5年間にわたる長期
② 進捗と、マイルストンを明確に定めた運営

Fiscal Year	FY20/21	FY21/22	FY22/23	FY23/24	FY24/25
	試行期間		実践期間		
成果1 橋梁点検・診断	マニュアル（案）	点検診断OJT	長大橋梁（円借款等）		
			▲ 橋梁点検車調達		
成果2 橋梁補修	マニュアル（案）	補修実施（パイロットプロジェクト3回）			
成果3 橋梁DB	橋梁DB開発（AI DB）				
成果4 人材育成	準備		TOT TOT TOT		
			エンジニア向けトレーニング 民間向けトレーニング		
成果5 予算改善	橋梁維持管理標準手順書（橋梁維持管理マニュアル（案））		ワークプラン	ワークプラン	ワークプラン

ベースライン

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本プロジェクト目指す成果

5. 橋梁点検・診断（成果1）に対する基本方針

① 技術者不足等の現状を踏まえて、実現しやすい手法（PBC、B-ARICS）
② 基礎データを早期に整備し、橋梁維持管理計画に活用（橋梁DB）
③ 詳細な定期点検は我が国の手法をベースに長大橋から着手
④ 新技術により点検の効率化、技術力不足の補完（本邦大学との連携）（DRIMS、ドローン）

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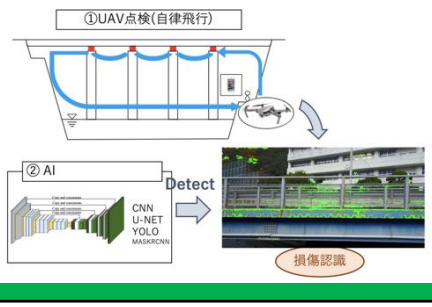
海岸道路および点検困難の橋梁



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最近の進展

THE 2ND BRIDGE INSPECTION SUB-WORKING GROUP MEETING
FOR
THE PROJECT FOR STRENGTHENING OF CAPACITY DEVELOPMENT ON BRIDGE MANAGEMENT SYSTEM IN THE REPUBLIC OF KENYA

Venue: VIRTUAL (ONLINE)
Date: THURSDAY, 19TH AUGUST 2021
Time: 9:00 AM

AGENDA

1. Prayers and Introduction
2. Opening Remarks (The JICA BMS Chief Advisor)
3. Reading and confirmation of the Minutes of the Previous Meeting
4. Tasks of the SWG members and Selection of the SWG Chair
5. Brief on Bridge Inspection Manual and Bridge Inspection Handbook
6. Progress Report on BMS Development (RoNHA/AfDB BMS team)
7. Drone Inspection Presentation (Dr. Dang, Saitama University)
8. Closing Remarks. Adjournment.

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Performance and Effectiveness

UAV BRIDGE INSPECTION

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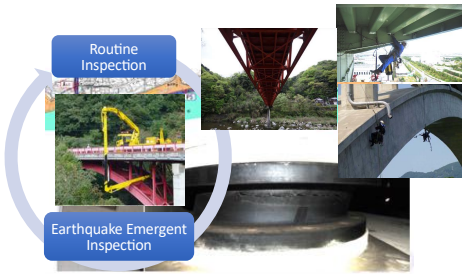
Bridge Vision Inspection



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High or Dangerous Place

From: NEXCO

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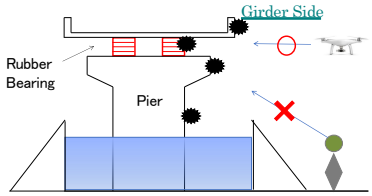
UAV Bridge Inspection



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Level of UAV Inspection

- Level 1: Control UAV, diagnose from pics
- Level 2: Deep learning damage detection
- Level 3: +Auto Report Writing
- Level 4: +Auto Pilot
- Level 5: +AI Plan (Time, Route, Action)
- Level 6: +Robot Repairing
- -> Fully Unmanned Bride Management

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What UAV can inspect

- Steel Bridge: Corrosion, Cracks, Fracture, missing bolts, stripped painting
- RC： Cracks, Spalling, Changing Collor

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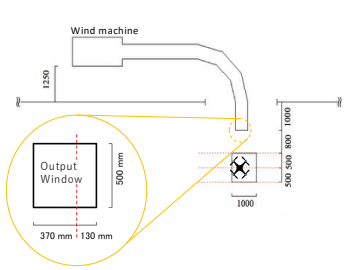
Test(3) Wind Tunnel Test



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Result(3) Wind resist V.S. Power

	Wr (m/s)	P/W	Rp
	2.5	1.95	1.05
	2.8	1.92	1.09
	6	2.29	0.776
	5	2.05	0.949

Rp=W/(P-W) W :Weight
P: Payload

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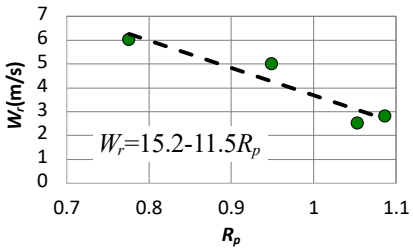
Result(3) Wind resist V.S. Power



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Performance Index

$$PI = Op + Sf + Vs$$

- PI • Performance Index
- Op • Operation performance
- Sf • Safety Performance
- Vs • Vision Performance

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Performance Evaluation

Op	30	Operation Time	15
		FPV	5
		Maximum Distance	5
		Maximum Speed	5
Sf	35	Wind Resistant	25
		Obstacle Avoidance	10
Vs	35	Photo Resolution	10
		Video Resolution	10
		Suspension Gimbel	5
		IOS	5
		Shutter Speed	5

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Performance Evaluation

	Op	*Sf*	*Vs*	*P*
	13.8	7.4	17	38.2
	13.1	6.1	14	33.2
	23.8	26.1	25	74.9
	22.4	20.6	25	68

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The Blue-cloud Bridge (Seiun Bashi)

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2016 Kumamoto Earthquake

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UAV Performance evaluation for resent models

M2z　　Mm　　MA

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Performance Evaluation

	項目(配点)	Mp	P4	M2z	Mm	Ma
Operer ation	飛行可能時間(15)	9	7	10	5	6
	FPV(5)	5	5	5	5	5
	最大伝送距離(5)	5	5	5	4	4
	最大飛行速度(5)	5	5	5	3	3
Safety	最大風速抵抗(25)	15	12	21	18	19
	障害物検知機能(10)	10	10	10	10	10
Visual	静止画　画素数(10)	6	6	6	6	6
	動画　解像度(10)	10	10	10	8	10
	ジンバル(5)	5	5	5	5	5
	ISO感度(5)	2	2	2	2	2
	シャッタースピード(5)	4	4	4	4	4
Performanc Index P(100)		76	71	83	70	74

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Bridges as Inspection Objects

No.	Bridge Type	Year	Length (m)	Damage Rank
1	Simple Supported Steel Plate Composite Girder	1963	40.0	3
2	Simple Supported Steel Plate Composite Girder	1962	29.1	3
3	RC Girder + RC Pier	1956	236.7	Unknown
4	Simple Supported Steel Girder	2001	60.2	3
5	Simple Supported Steel Plate Composite Girder	1962	40.5	3
6	Simple Supported Steel Plate Composite Girder	1968	40.7	2
7	Simple Supported Post Tension Concrete Girder	1960	50.1	2
8	Simple Supported Steel Plate Composite Girder	1958	17.0	1
9	Simple Supported Steel H Girder	1972	26.0	2
10	Simple Supported Steel Girder	1970	26.7	2
11	Steel Arch Bridge	1971	99.0	3
12	Simple Supported Steel Plate Composite Girder	1956	59.7	3
13	Simple Supported Post Tension Concrete Girder	1980	89.3	3

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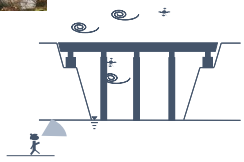
What UAV NEED?

Satellites (GPS)



What UAV NEED?

- Safe place for take off and landing
- Safe place where operator can stand
- Satellites connecting
- Weather

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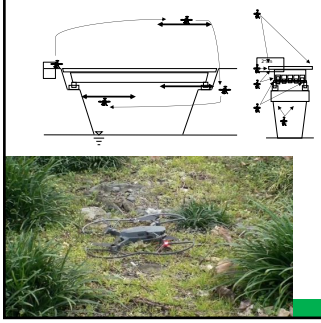
Procedure



UAV Inspection Flow

Take off

↓

Out side member photos:
Road Surface, Side of Railing, Girder Beam Side view.
(Keep 2~3 m distance)

↓

Inside Superstructure Members Surface: Girder Bottom, Inner Girder, Deck.
(Only if possible)

↓

Piers, Abutment, Walls

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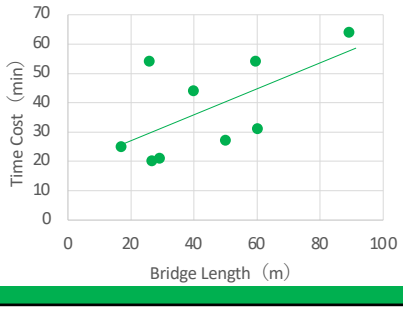
Total Inspection Time



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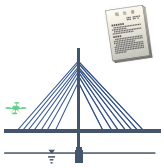
Detection Accuracy

Compare with human manual inspection reports

$$P = \frac{\Sigma D_3}{\Sigma D_1}$$



P ：Percentage of UAV finds the damages that human reported

D_1 ：Detect Damage Numbers by Reports

D_3 ：Number of damages in D1 that also detected by UAV

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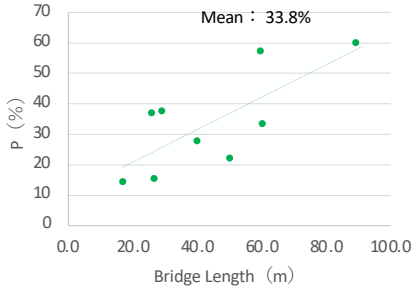
Detection Accuracy



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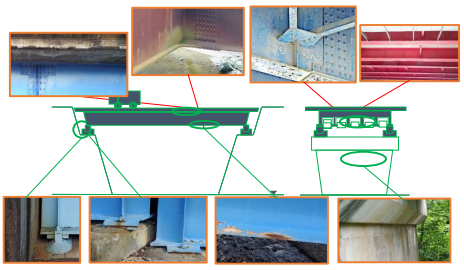
Steel Girder Bridge



・・・UAV

・・・Reports

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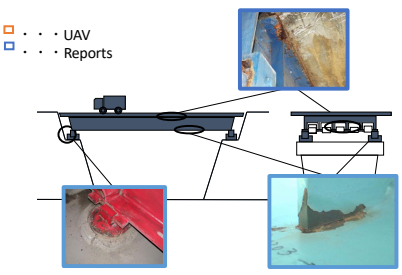
Steel Girder Bridge



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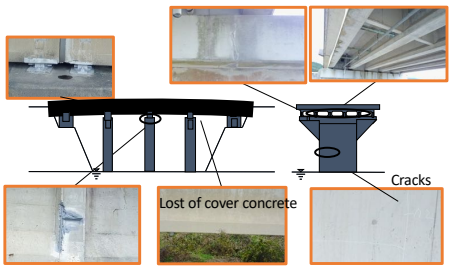
RC, PC Girder Bridge



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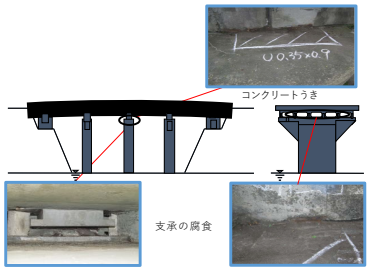
RC, PC Girder Bridge



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Location

UAV can confirm
UAV can not (difficult) to see

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Autopilot base bridge inspection

大洋測量
https://taiyo-s50.jp/publics/index/38/

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Waypoint Assignments

Map in the operation interface

Assign some waypoints on operation interface

- Height
- Camera Setting
- Speed

Set all points

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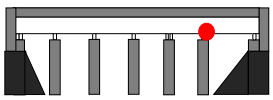
Waypoint Recording



Flight to the point manually

Adjust location and camera

Set Speed

Record the point

Set all points one by one

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Onsite verification for UAV Autopilot Inspection

J Bridge

Length	833.1m
Width	12.5m
Span	68.7m
Structure	13 Span Steel Box Girder Bridge

- Location：J Bridge in Saitama
- Time：11:00 AM
- Operator：3

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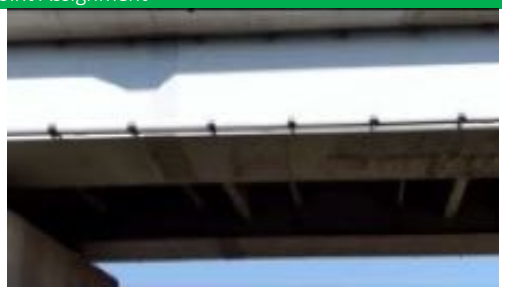
Waypoint Assignment



Deck and Box Girder Bottom side (2xt)

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点検②

自律飛行（Waypoint記録型）で撮影できた橋梁（2倍速）

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Results General Inspection Operators needed for Manual Inspection

	Telescope Inspection (pre)	Close Inspection	
		Inspection Vehicles	Other Machines
Inspection Operators	1人	1人 1)	1人 2)
Inspection Assistants	2人	2人 1)	2人 2)
Inspection vehicle operator	—	1人 1)	—
Traffic Control Staff	—	3)	—

Note 1) Bridge inspection vehicles, etc .: Range required for inspection, traffic conditions, bridges and equipment used
Determine the appropriate organization personnel in consideration of the conditions.
Note 2) Other facilities: When using inspection roads, ladders, ships, painted scaffolding, etc.
Determine the number of trainees in consideration of the local situation and inspection method.
Note 3) Traffic control staff: Considering the traffic conditions at the inspection site, inspection methods, etc.
Determine the number of people to organize.

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点検種別による利点と欠点

	手動制御	自律飛行（Waypoint指定型）	自律飛行（Waypoint記録型）
利点	● 撮りたい箇所が撮れる	● 最も時間がかからない ● 映像が滑らか ● 操作方法が簡単 ● 周囲確認の余裕がある	● 映像が滑らか ● 撮りたい箇所を撮れる ● 周囲確認の余裕がある
欠点	● 操作技術が求められる ● 映像がカクカクする ● 周囲確認の余裕がない	● 地図上で飛行ルートを作成するので１m弱の誤差が出る ● 対象物の高度がわからないと飛行高度が設定できない	● 二度飛行するので時間がかかる(ルートが保存できるので初回の飛行のみ)

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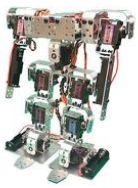
For narrow spaces

Mm P=70
Mass=199g



Mini Robots

https://prod.kyohritsu.com/av.html

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IoT +UAV

- 上向けカメラを装着し
- ラズパイからWifiで繋ぐ
- 指令送信で制御

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For UAV images

DEEP LEARNING BASED DAMAGE DETECTION

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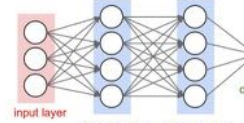
experience

Remember features of each Neural Network



Cat

Car

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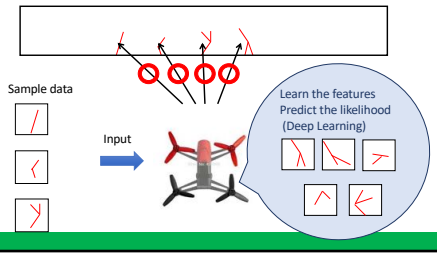
Structural Damage Feature



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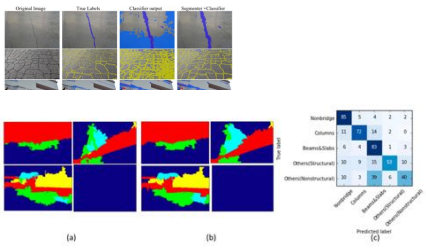
Structural Damage Detections DL



V. Hoskere, Y. Narazaki, T.A. Hoang, B.F. Spencer Jr, 2017

Y. Narazaki, V. Hoskere, T.A. Hoang, B.F. Spencer Jr, 2017

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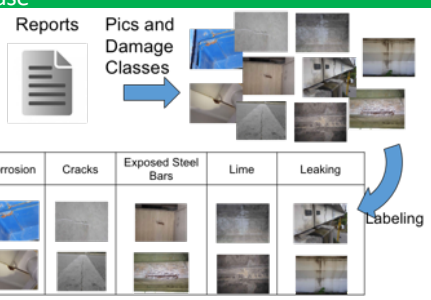
Data Base



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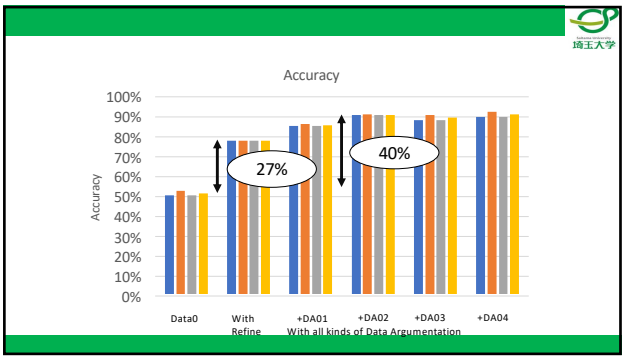

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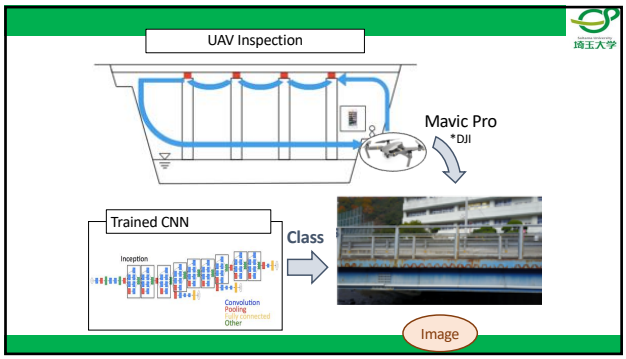

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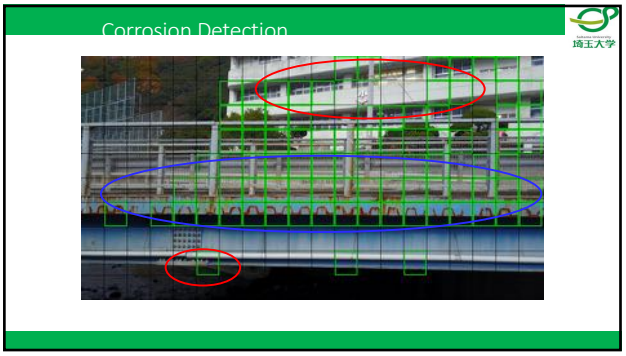

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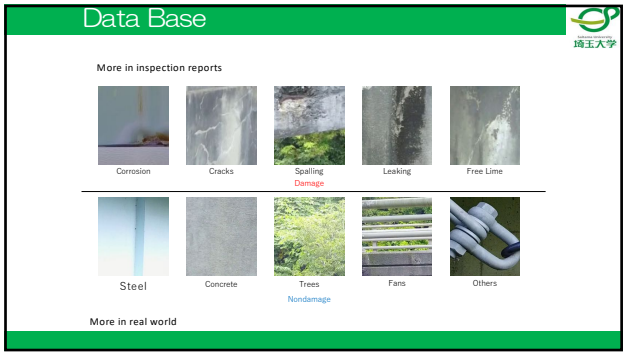

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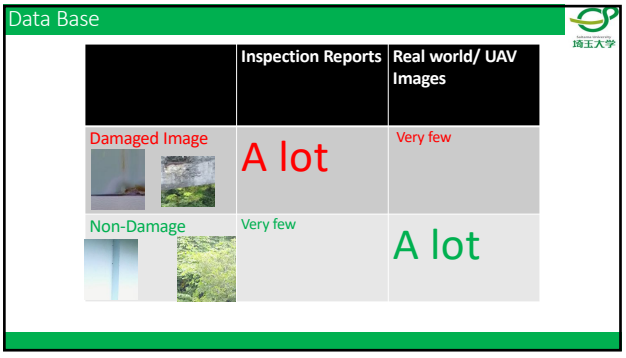

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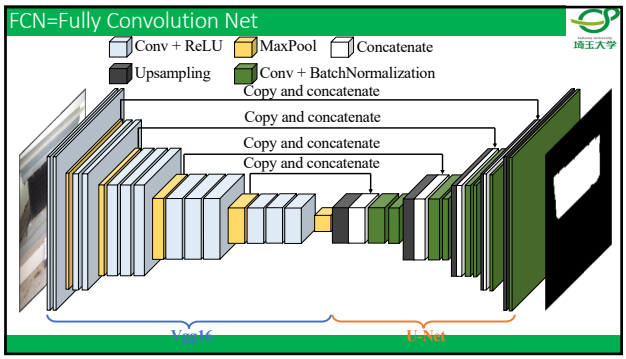

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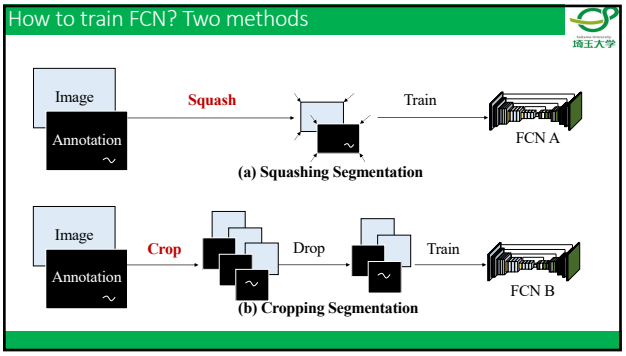

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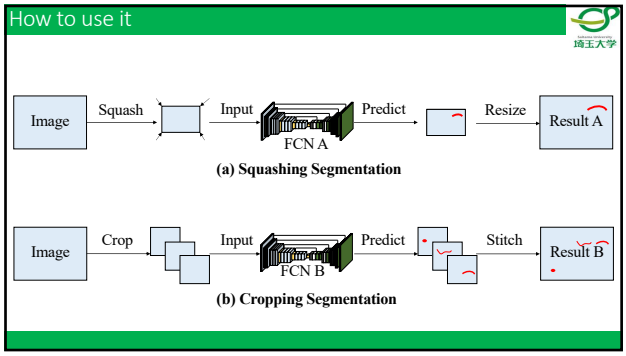

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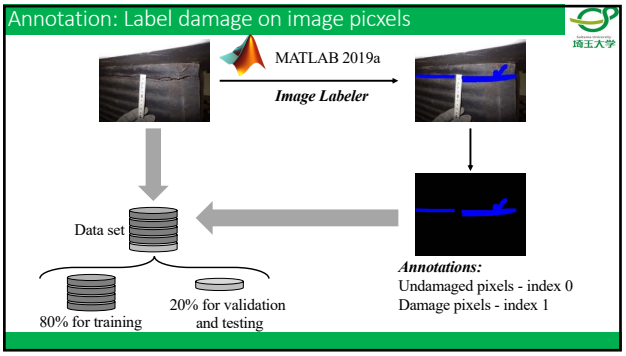

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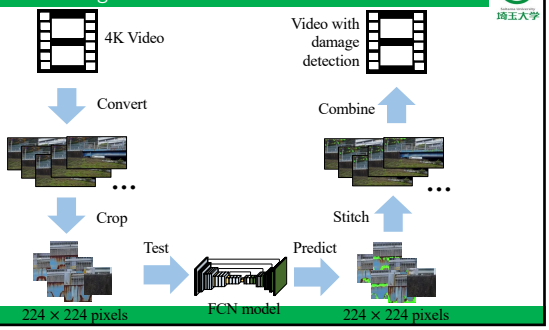
UAV video marking



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UAV video marking

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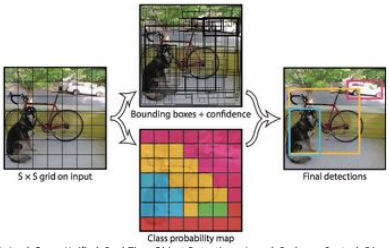
You Only Look Once(YOLO)



You Only Look Once: Unified, Real-Time Object Detection—Joseph Redmon, Santosh Divvala, Ross Girshick, Ali Farhadi
University of Washington, Allen Institute for AI, Facebook AI Research

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Some Preliminary Results

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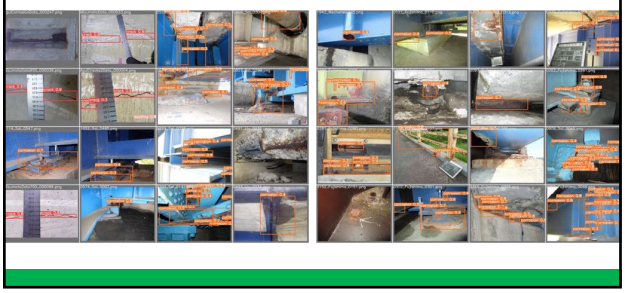
YOLO v5s



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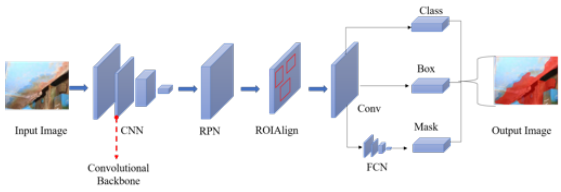
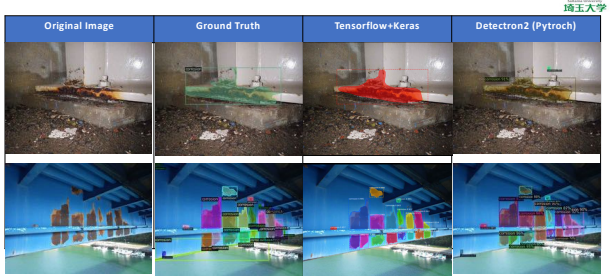
Architecture of Mask R-CNN



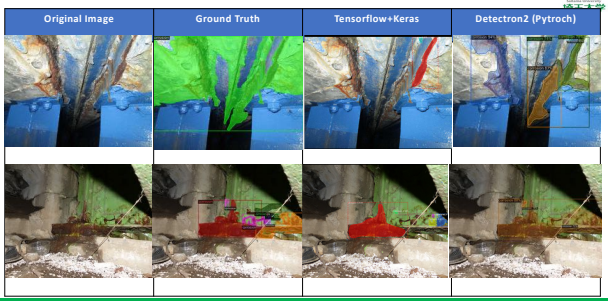
66

Detection Result Comparison



67

Detection Result Comparison



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Test on UAV Video

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Thank you for listening

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