UNIVERSITY OF MESSINA

YEAR-END GENERAL PROGRESS EVALUATION PRESENTATION OF THE UNIVERSITY OF MESSINA DOCTORAL PROGRAM

VEDAT ELBİR

Idea of Restoration

Stucking the restoration Process (Restrictions)

1) Relevée (Surveying) ➕ 2) Restitution (Preparation of the project) ➕ 3) Physical intervention (Restoration)
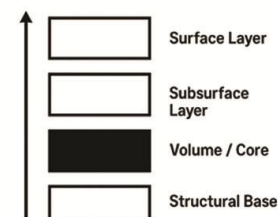
❯ Deterioration Detection

❯ Structural Health Monitoring

❯ Coloring of damaged and deteriorated surfaces

❯ Filling small loss (gaps or cracks, etc) on surfaces

❯ Repair of damaged parts of buildings whose parts, roofs, walls, or coverings have collapsed
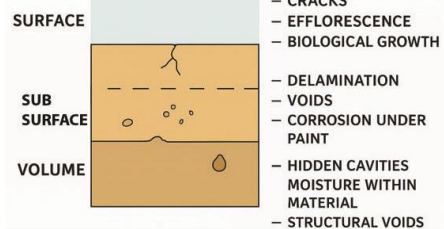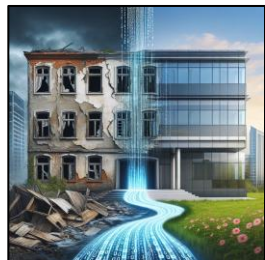
Deterioration Detection

SURFACE	– CRACKS – EFFLORESCENCE – BIOLOGICAL GROWTH
SUB SURFACE	– DELAMINATION – VOIDS – CORROSION UNDER PAINT
VOLUME	– HIDDEN CAVITIES MOISTURE WITHIN MATERIAL – STRUCTURAL VOIDS

Wall Thickness Representation

- Surface Layer
- Subsurface Layer
- Volume / Core
- Structural Base

Partially Destructed CH Buildings

Consolidation according to inherited features
- **Carlo Fea** (1753-1836)
- **Antonio Canova** (1757-1822)

Consolidation with contemporary approaches

Main Deteriorations
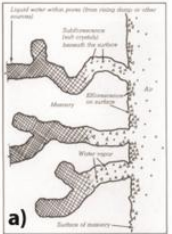
A total of **33** different types of deterioration have been examined on CH buildings specifically in Italy.

| Deteriorating Type	Picture	Deterioration's Occurrence	In Which Layer of The Structure It Occurs	References
Earthquake-based cracks and collapses		The earthquakes seen constantly cause cracks or collapses in CH structures. Also, an example is seen. This example shows the earthquake that occurred on 30 October 2016 in Norcia. In this earthquake, besides a lot of buildings being damaged with cracks, Palazzo Comunale (Town Hall), which is located on the left of the church, collapsed.	Surface + interior (structural)	(Valensisea, Tarabusia, Guidobonib, & Ferraria, 2017),
Salt crystallisation on the brick masonry		Structures are deeply exposed to tidal exchange and capillary rise on the wall surfaces, and water condensation-evaporation cycles. And, over time, these continuous processes have caused the crystallization of salt has changed the chemical situation of the brick material. This situation is easily seen with a colour change.	Surface + near-surface volume	(Coletti, ve diğerleri, 2023), (Tagliapietra, 2025), (Rossi, Fagarazzi, Spinelli, Pompeo, & Gjelaj, 2025)
Biological colonisation caused by dense climatic factors and the mineralogical situation of rocks, mortars, limestones, and gypsum		Southern Italy, Campania, Calabria, Puglia, and Sicily, where it is suitable for be growth of the Ailanthus Altissima, Ficus Carica, Fungi, Cyanobacteria, and Green Algae (Mazzeo, Magarelli, & Ferrara, 2024)	Surface + near-surface volume	(Gaylarde, 2020), (Andera, 2026), (Matteuzzi, 2024), (Elgohary, Mansour, & Salem, 2022)
Water damage that resulted from the flood and rising damp (Capillary Rise)		Water damage that resulted from the flood and rising damp (Capillary Rise).	Surface + internal volume	(Juerginho, 2025)
Subflorescence: A) The salt and water vapour penetrate to the pores of the construction material. B) The colour exchange of the surface owing to subflorescence		In sub florescence, the hazardous process is developed hiddenly. Soluble salt is accumulated beneath the masonry surface through evaporation of water in the moisture. Evaporation occurs in crystallized salt-degrading construction material. Besides, due to weather conditions, the moisture freezes, leading to continuous expansion and contraction, which degrades the structural materials' content.	Surface volume	(Russa & Ruffolo, 2021), (Grimmer, 1984)

"Types of deterioration commonly encountered at high rates in certain areas."

Critical Restoration Theory
- Cesare Brandi (Siena),
- Renato Bonelli (Rome),
- Giulio Carlo Argan (Turin),
- Roberto Pane (Naples).
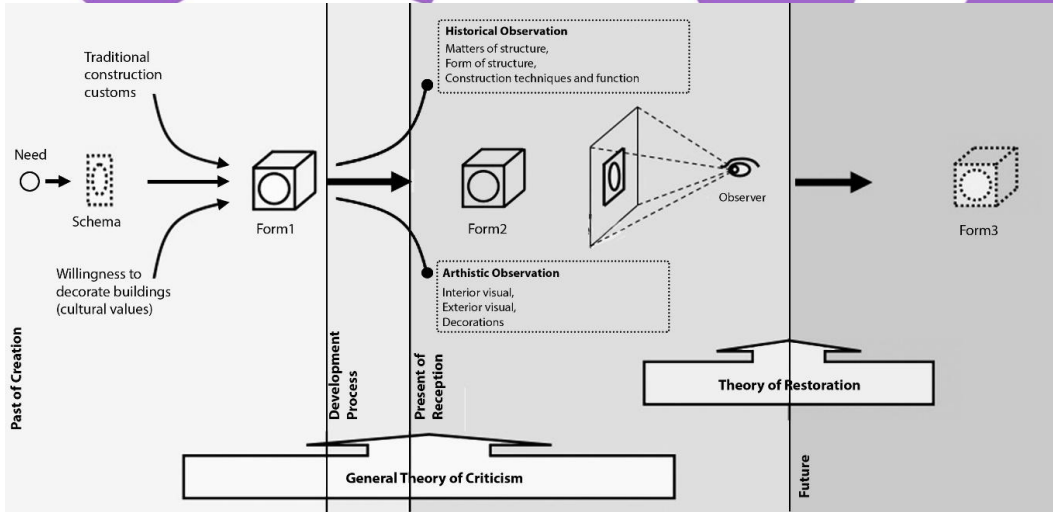
CH Building's (Architectural Styles)

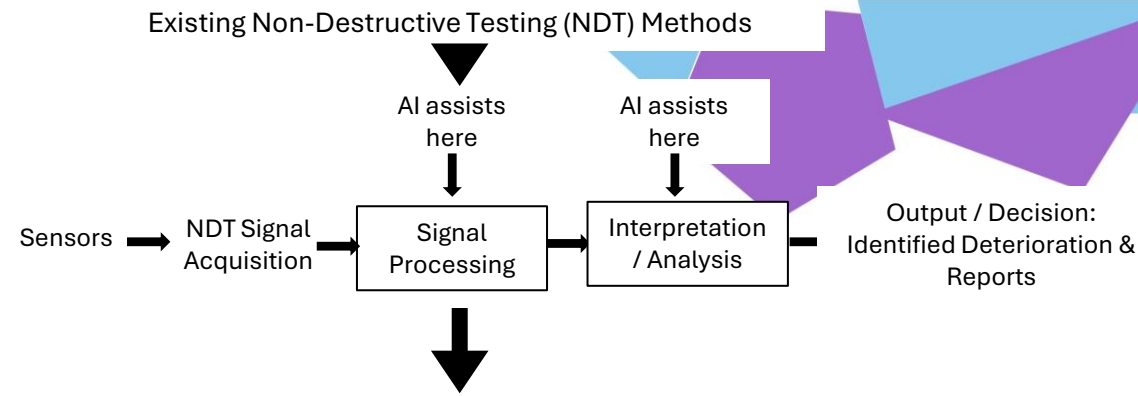Possible by;

Guessing patterns, symmetries, and learned shapes

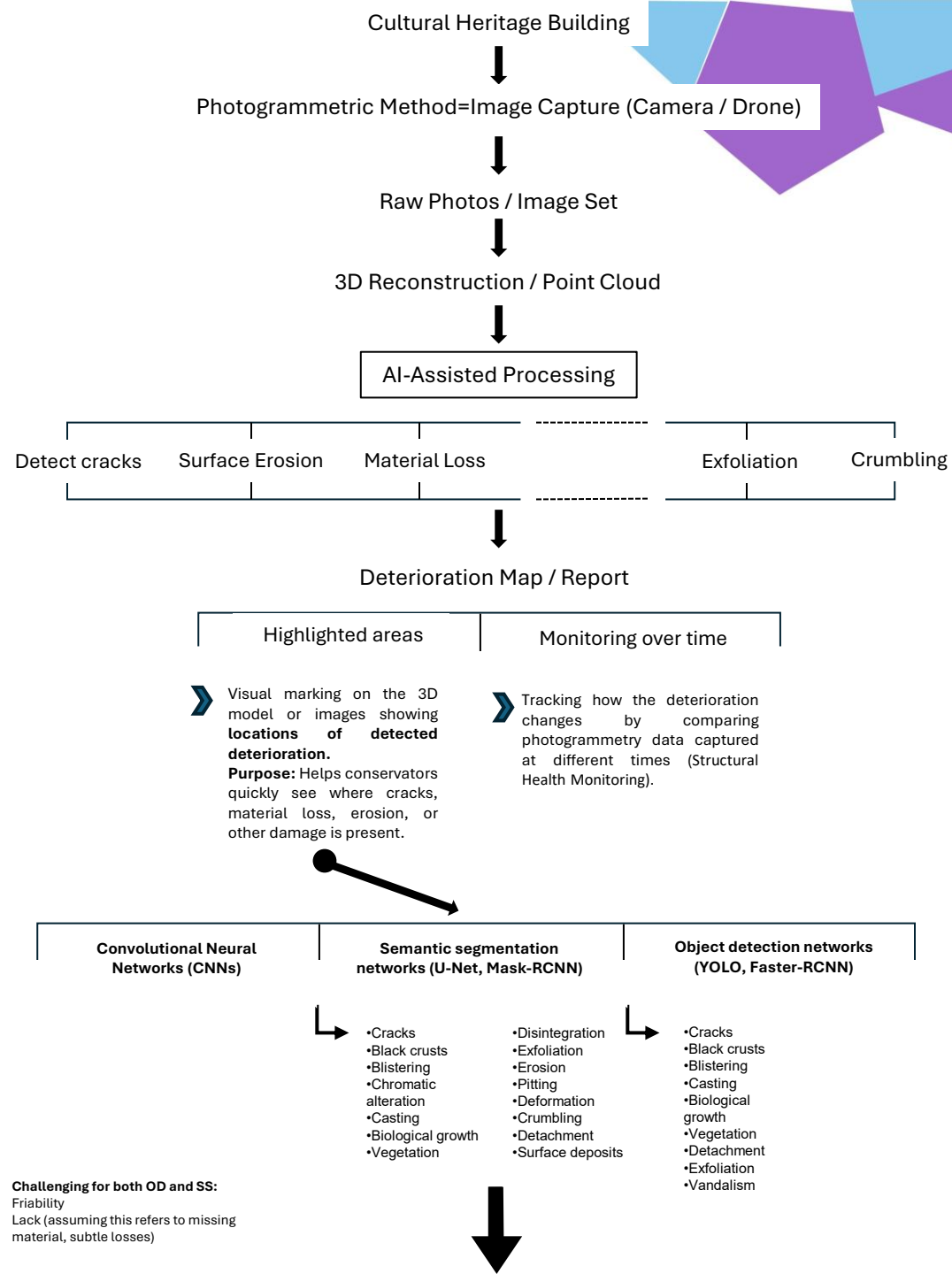Hybrid workflows are used

Photogrametry

NeRF (Neural Radiance Field)

3D-CNN   Paint Cloud Completition

18 dicembre 2025

Existing Non-Destructive Testing (NDT) Methods

AI assists here → Signal Processing

AI assists here → Interpretation / Analysis

Sensors → NDT Signal Acquisition → Signal Processing → Interpretation / Analysis → Output / Decision: Identified Deterioration & Reports

$$\text{Achievement \%} = \frac{\text{Number of deterioration types detected}}{33 \ \text{total deterioration types}} \times 100$$

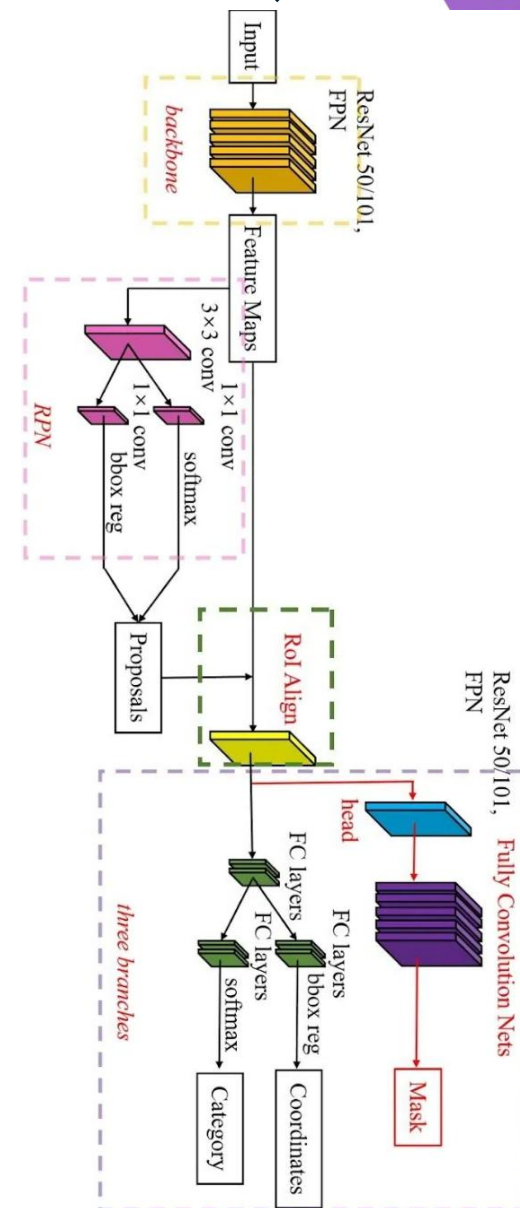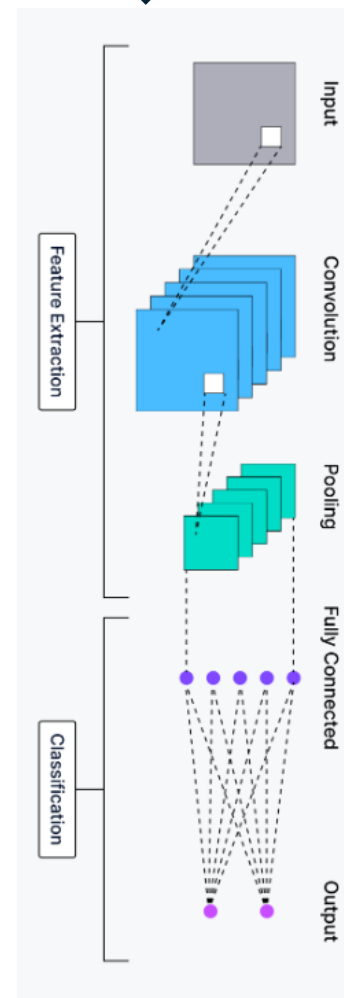| NDT Method	NDT Type	Detectable Layer(s)	Detectable Deteriorations	Achievement %
Visual Inspection	Geometric	Surface	Cracks, Black crusts, Blistering, Chromatic alteration, Casting, Biological growth, Vegetation, Crumbling, Detachment, Surface deposits, Disintegration, Exfoliation, Erosion, Friability, Sugaring, Encrustation, Stains, Vandalism	54%
Photogrammetry	Geometric	Surface + Surface Volume	Cracks, Black crusts, Blistering, Chromatic alteration, Casting, Biological growth, Vegetation, Deformation, Crumbling, Detachment, Surface deposits, Disintegration, Exfoliation, Erosion, Friability, Lack, Pitting	52%
Laser Scanning	Geometric	Surface + Surface Volume	Deformation, Erosion, Lack, Cracks (macro), Surface loss	15%
Sensors		surface Volume	Subflorescence, Salt crystallization, Moisture staining	
Microwave Moisture	Electromagnetic	Near-surface Volume	Moisture damage, Salt crystallization, Dampness, Subflorescence	12%
Spectroscopy	Electromagnetic	Surface	Salt crystallization, Black crust, Chromatic alteration, biological colonisation, Encrustation, Stains, Patina, Pollution crusts	24%
Vibration Monitoring	Acoustic / Mechanical	Interior Surface + Interior	Structural cracks, Deformation, Detachment, Dynamic instability	12%

Cultural Heritage Building

⬇

Photogrammetric Method=Image Capture (Camera / Drone)

⬇

Raw Photos / Image Set

⬇

3D Reconstruction / Point Cloud

⬇

AI-Assisted Processing

| Detect cracks | Surface Erosion | Material Loss | ---------------- | Exfoliation | Crumbling |

⬇

Deterioration Map / Report

| Highlighted areas | Monitoring over time |

❯ Visual marking on the 3D model or images showing **locations of detected deterioration.**
Purpose: Helps conservators quickly see where cracks, material loss, erosion, or other damage is present.

❯ Tracking how the deterioration changes by comparing photogrammetry data captured at different times (Structural Health Monitoring).

| **Convolutional Neural Networks (CNNs)** | **Semantic segmentation networks (U-Net, Mask-RCNN)** | **Object detection networks (YOLO, Faster-RCNN)** |

Semantic segmentation networks (U-Net, Mask-RCNN):

• Cracks
• Black crusts
• Blistering
• Chromatic alteration
• Casting
• Biological growth
• Vegetation

• Disintegration
• Exfoliation
• Erosion
• Pitting
• Deformation
• Crumbling
• Detachment
• Surface deposits

Object detection networks (YOLO, Faster-RCNN):

• Cracks
• Black crusts
• Blistering
• Casting
• Biological growth
• Vegetation
• Detachment
• Exfoliation
• Vandalism

Challenging for both OD and SS:
Friability
Lack (assuming this refers to missing material, subtle losses)
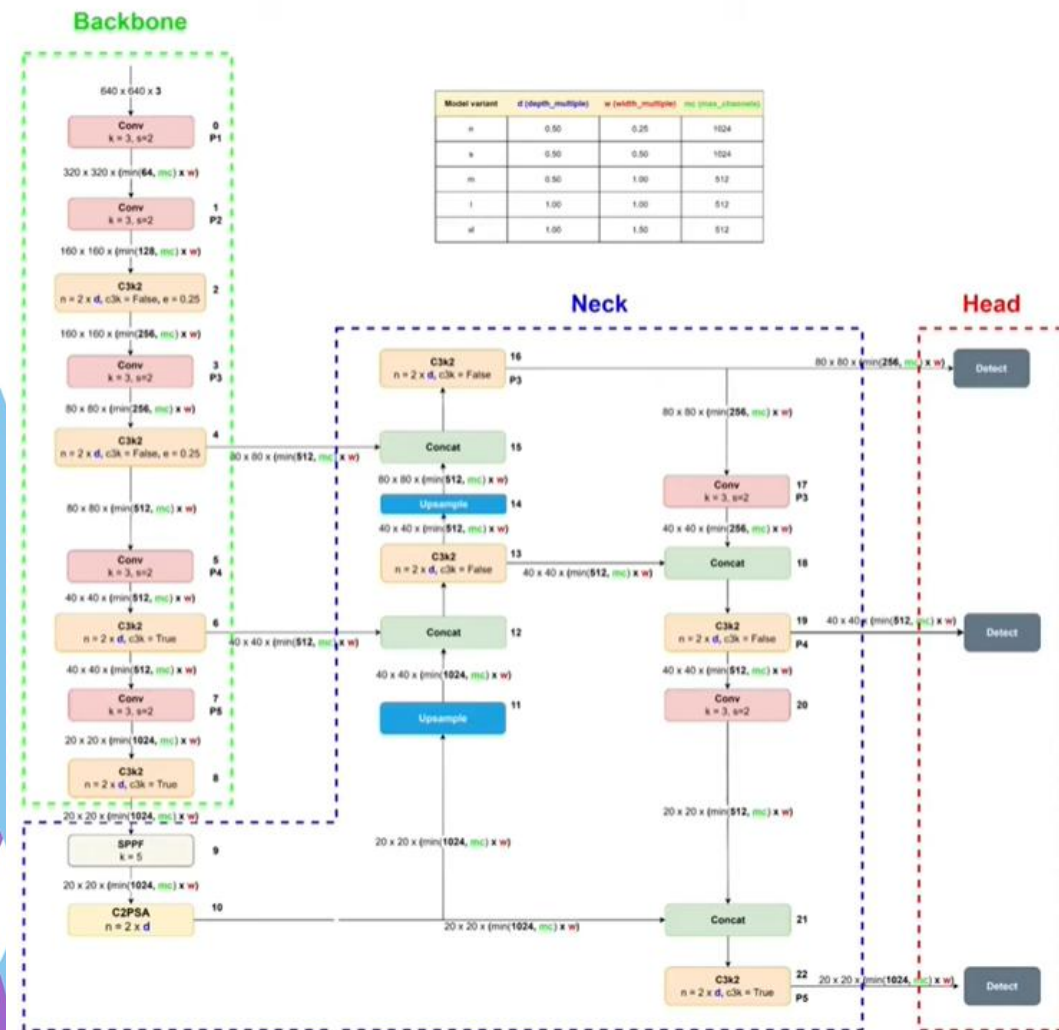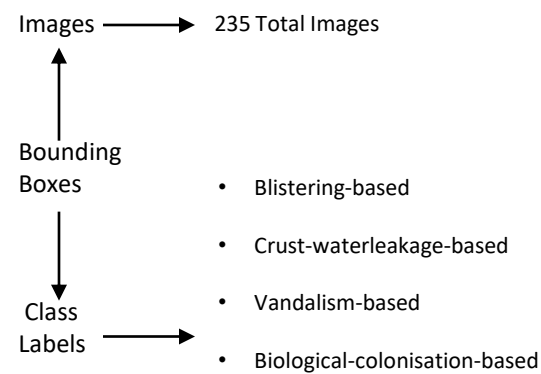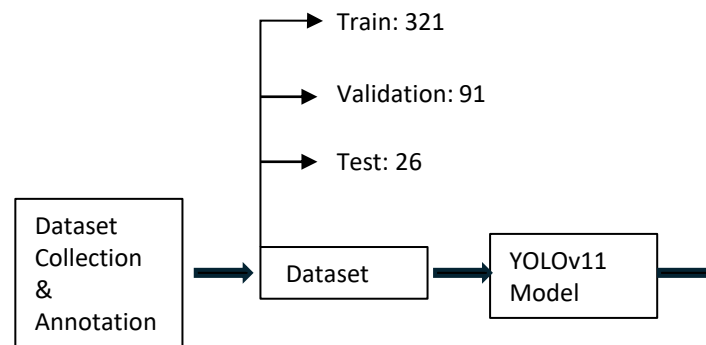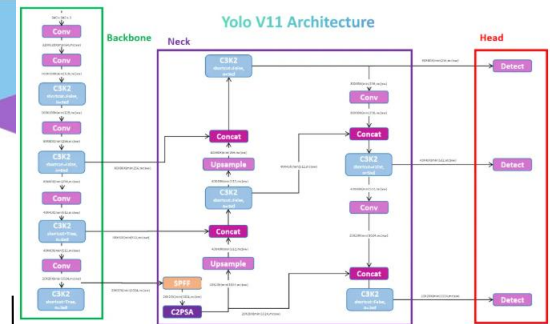
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Object detection networks (YOLO, Faster-RCNN)

Convolutional Neural Networks (CNNs)
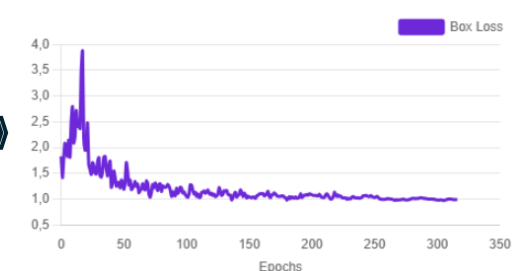
Semantic segmentation networks (U-Net, Mask-RCNN)
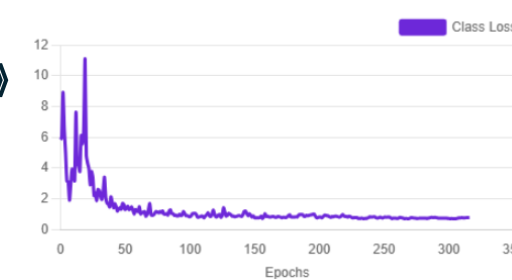
Object detection networks (YOLO, Faster-RCNN)

Yolo V11 Architecture

Backbone | Neck | Head

Training Step

Loss Calculation (from Head Outputs)

Train: 321

Validation: 91

Test: 26

Dataset Collection & Annotation

Dataset

YOLOv11 Model

Images → 235 Total Images

Bounding Boxes

Class Labels

- Blistering-based
- Crust-waterleakage-based
- Vandalism-based
- Biological-colonisation-based

Box Loss

Box Loss

Class Loss

Class Loss

Object Loss

Object Loss

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Validation Step

Head Predictions vs Ground Truth

Model Performance

mAP   mAP@50:95

Backward Pass & Weight Update (Training Only)

Graphical Visualization
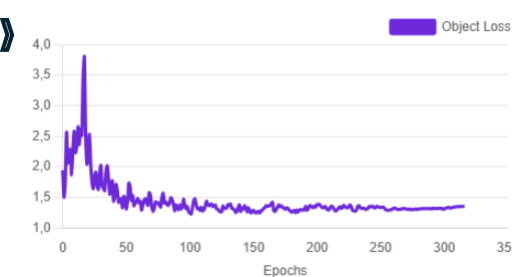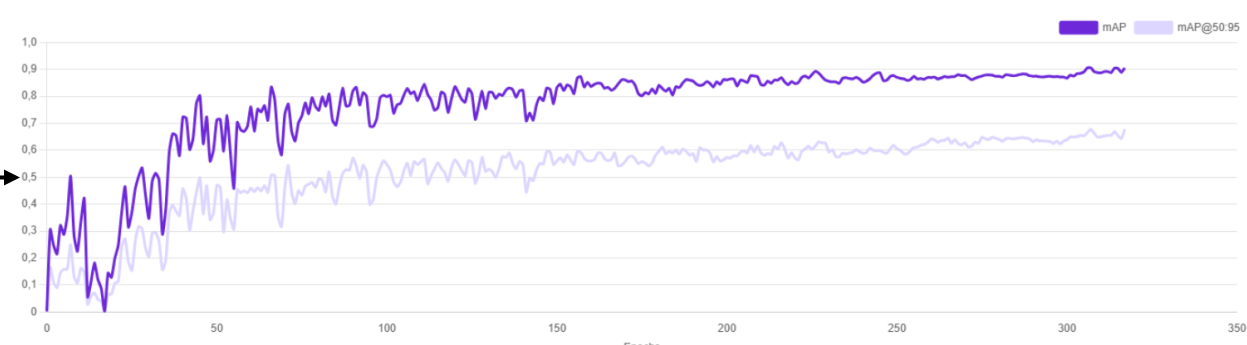
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Continuation of examination of object detection and semantic segmentation models

Learning semantic segmentation models

Dataset preparation and diversification

Sellection of CH Buildings

The buildings will be chosen according to deterioration styles

The definition of the achievement rate of deterioration detection models will be interpreted

Thank You