

# Thermal Imaging Applied to Building Pathology Documentation: An Initial Modeling Approach



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## BACKGROUND:

- **Construction:** 1/3 of world's natural resources; 40% of all landfill waste<sup>1</sup>
- **LEED Platinum buildings, Material & Resources:** lowest scoring category<sup>2</sup>
- **Carbon footprint:** reusing is smaller than demolishing and building<sup>3</sup>
- Encouraging the reuse of existing buildings is a relevant, contemporary, and **urgent subject**<sup>4</sup>
- **NYC One City Built to Last:** buildings that should last well **beyond 2050:** energy efficiency is key<sup>5</sup>
- **Costs:** reusing is **not** sure cheaper than demolishing and rebuilding<sup>6</sup>
- **Identifying pathologies:** first step of rehabilitation (**infrared thermography**)
- **Radiation X temperature:** accuracy depends on **emissivity** of materials
- **Thermal images:** may be **difficult to interpret** (emissivity, image angle, heat/light sources, etc.)

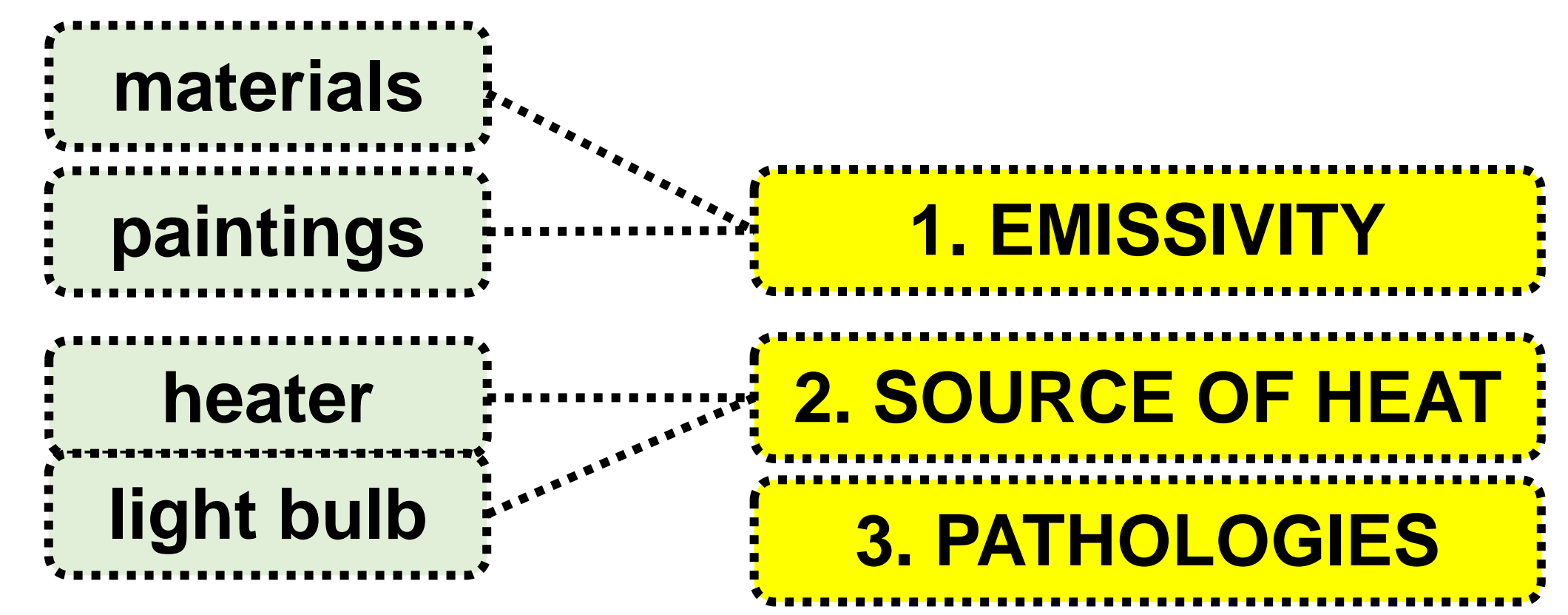
## GOAL:

- Create **AI Model** to identify materials and ultimately **map pathologies** of one particular building - future application in other buildings

## METHODS:

- Categorize **materials, emissivity values, paints, and sources of heat** to minimize errors ( $e=0.95$ )
- Categorize **pathologies**
- Use **HTI Thermal Imaging Camera (HT-18)** for thermal and regular images of the building (*LCD resolution: 320x240; thermal sensitivity: 0.07°C*)
- **Map pathologies in AutoCAD and SketchUp**
- **Level of detail** for recording heritage structures<sup>7</sup>: **Initial/Reconnaissance**
- Photographs: **Feb 23, 2022, 9am** (cloudy, 31.9°F, 46% of relative humidity)

## Considerations for the AI model:



## RESULTS:

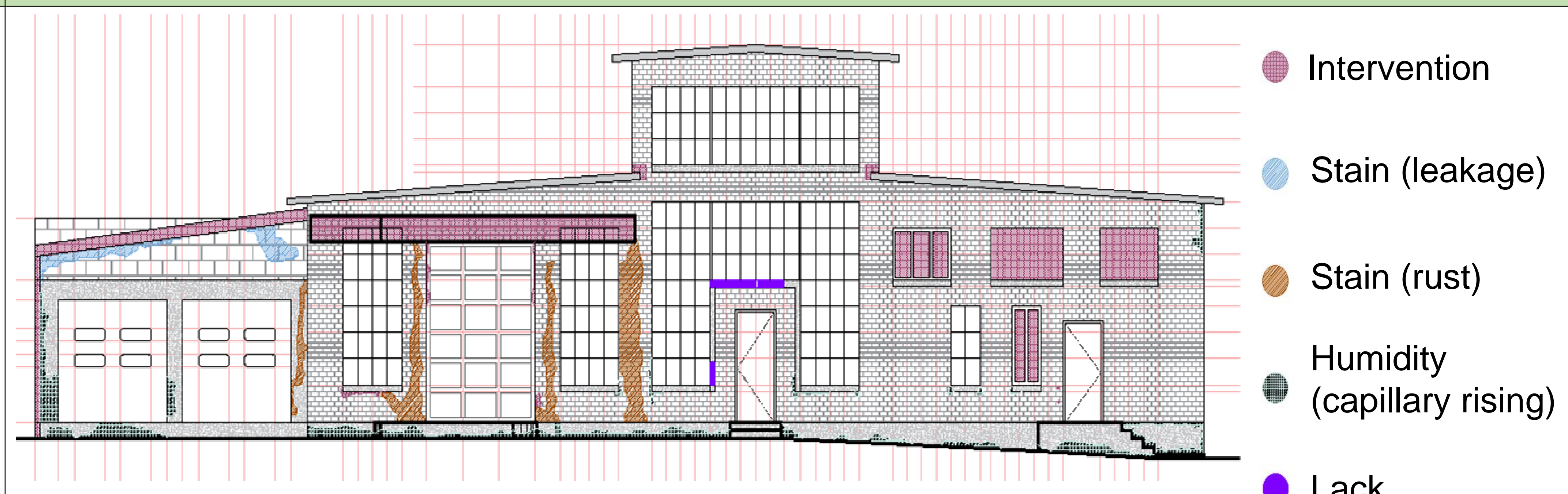


Figure 2: South Façade Damage Map – Pathologies in AutoCAD

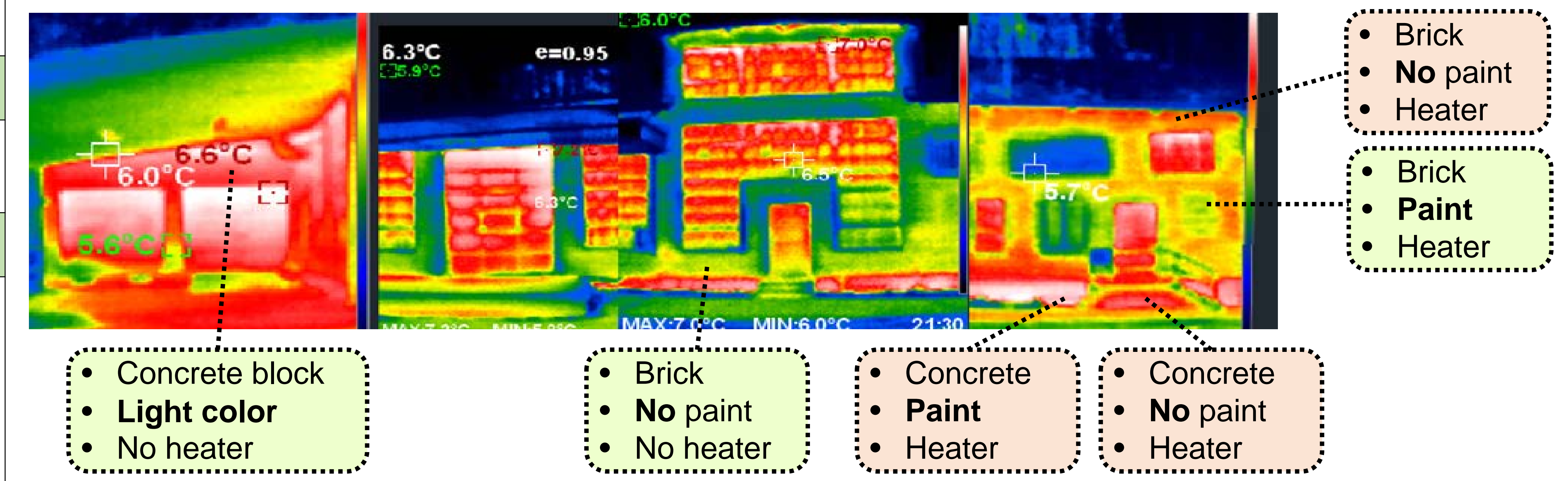


Figure 3: South Façade Infrared Thermal Images – Compilation



Figure 4: South Façade Photographs – Compilation



Figure 5: Heat Sources in the Building

## AI MODEL OUTCOME:

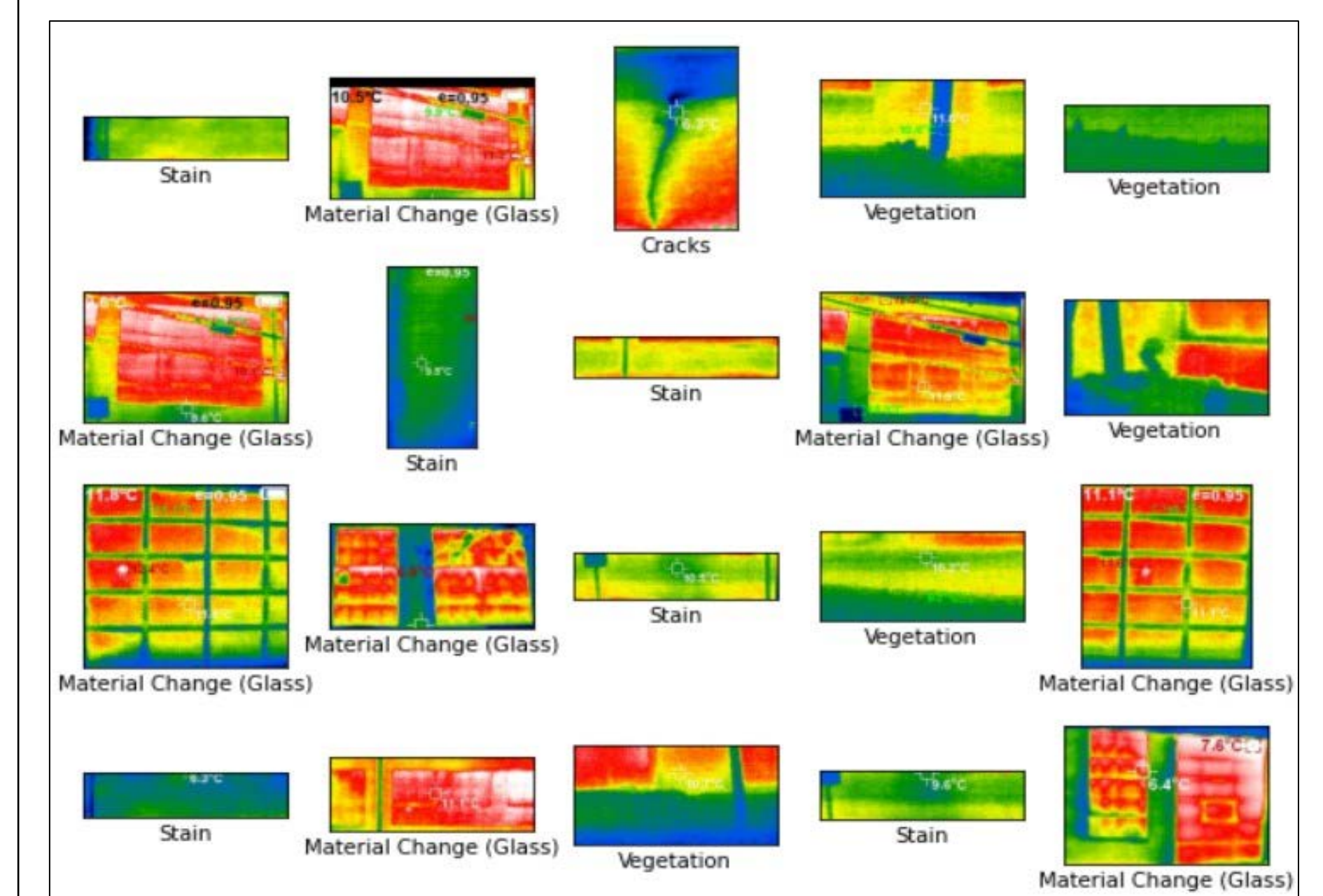


Figure 7: Training the Image Recognition Model

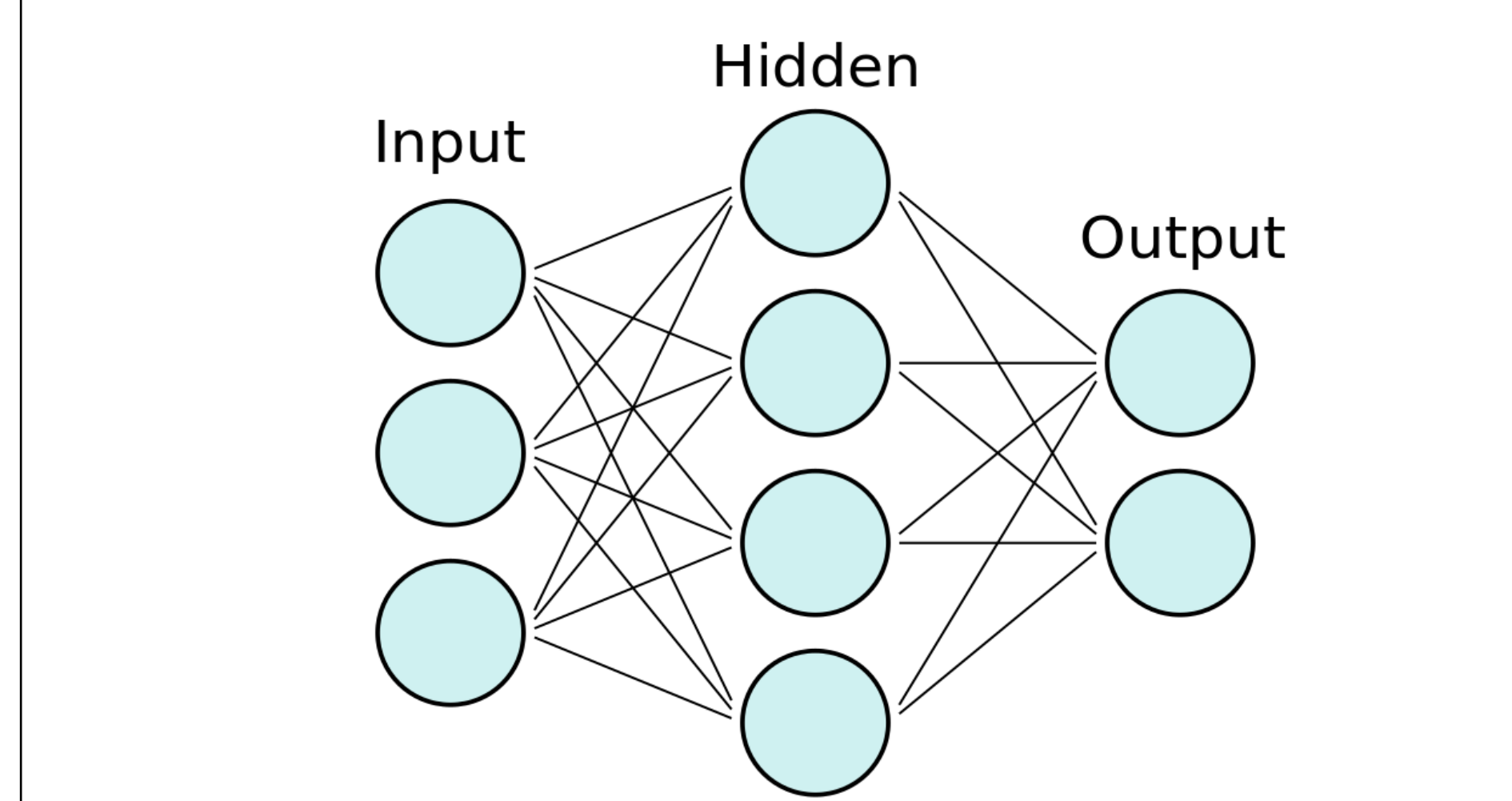


Figure 8: Sequential Image Recognition Model

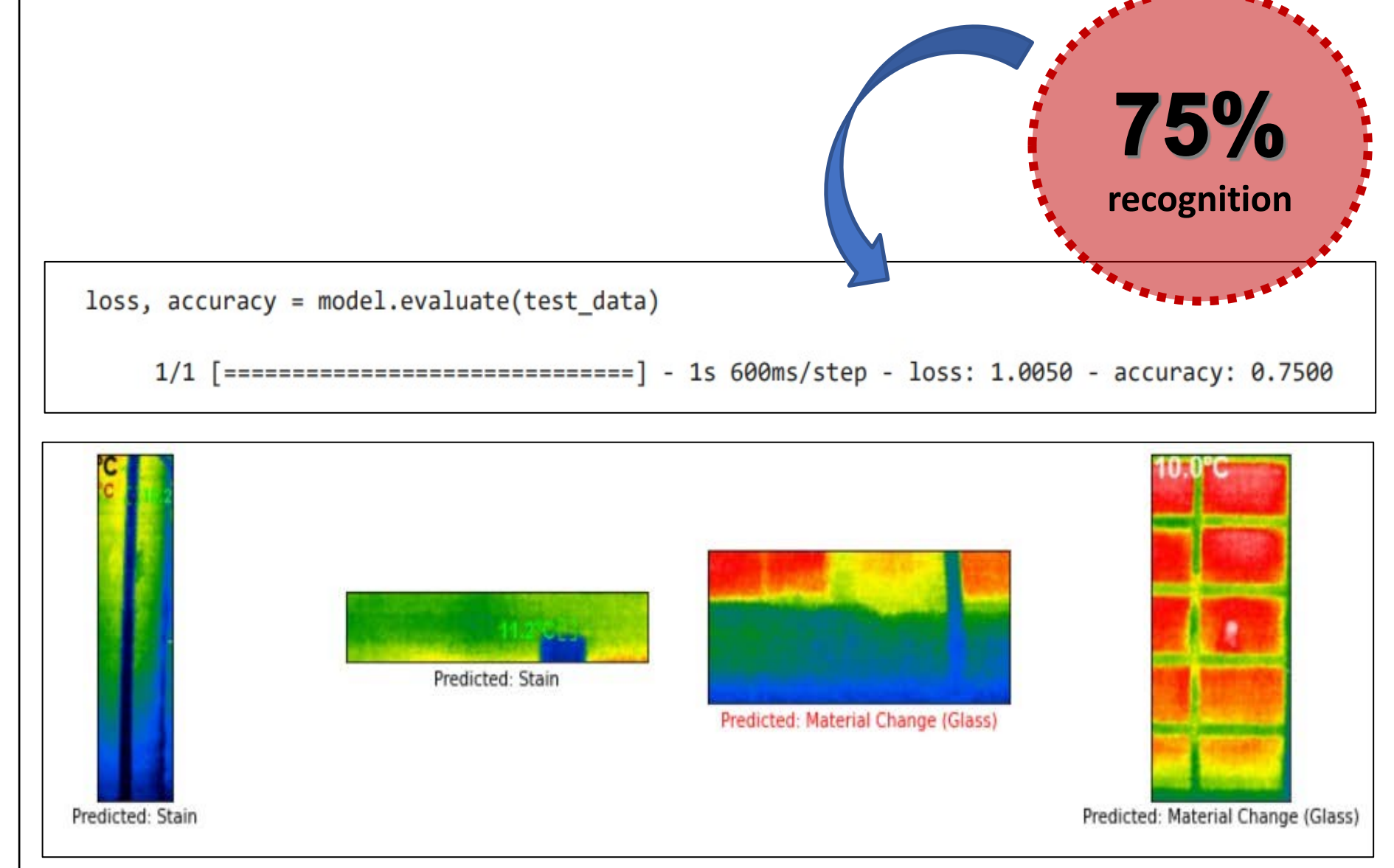


Figure 9: Image Recognition Model Results

## Methodology for Figure 1:

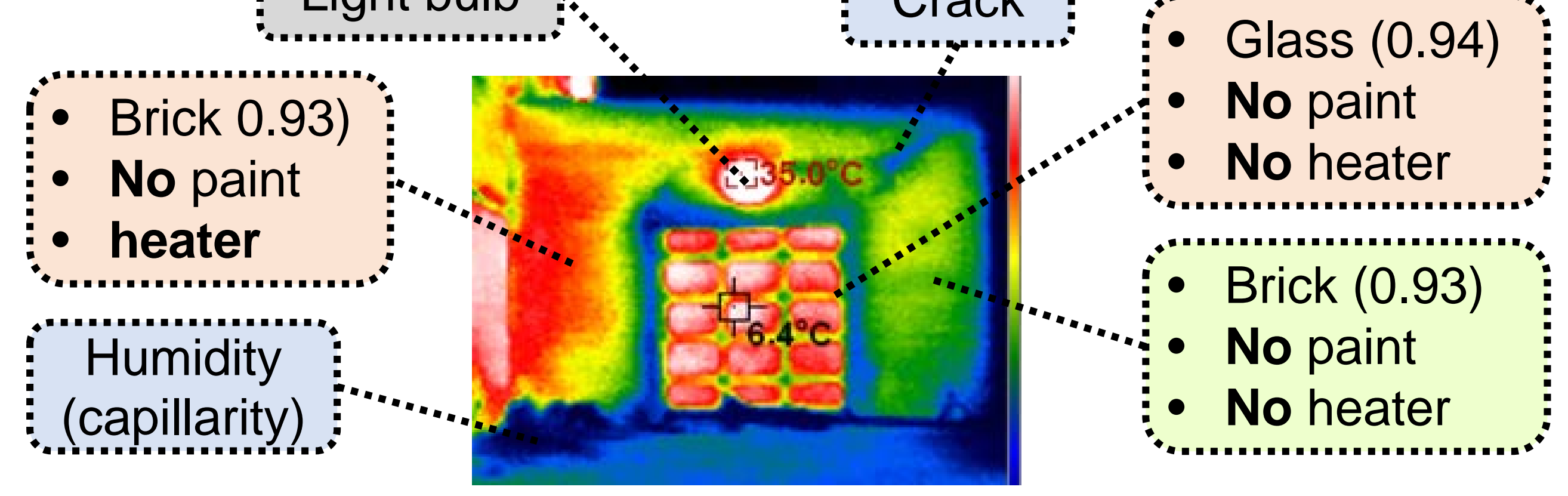


Figure 1: East Façade IRT Image – Method

## REFERENCES:

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<sup>2</sup>Da Silva, L., & Ruwanpura, J. (2009). Review of the LEED Points Obtained by Canadian Building Projects. *Journal Of Architectural Engineering*, 15(2), 38-54. doi: 10.1061/(asce)1076-0431(2009)15:2(38)  
<sup>3</sup>EPA Region 9 (Pacific Southwest) | US EPA. (2022). Retrieved 13 March 2022, from <https://www.epa.gov/aboutepa/epa-region-9-pacific-southwest>  
<sup>4</sup>Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme (2019): 2019 Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector.  
<sup>5</sup>One City: Built to Last. (2022). Retrieved 13 March 2022, from <https://www1.nyc.gov/site/builttolast/index.page>  
<sup>6</sup>Douglas, J. (2006). *Building adaptation* (2nd ed.). Butterworth-Heinemann; Hall, P. G. (1998). *Cities on civilization*. London: Wiedenfeld and Nicolson; Kohler, N., & Yang, W. (2007). Long-term Management of Building stocks. *Building Research & Information*, 35(4), 351e362.  
<sup>7</sup>Napolitano, R., Hess, M., & Glisic, B. (2019). Quantifying the Differences in Documentation and Modeling Levels for Building Pathology and Diagnostics. *Archives Of Computational Methods In Engineering*, 27(4), 1135-1152. doi: 10.1007/s11831-019-09350-y  
<sup>8</sup>Arashpour, M., Ngo, T. and Li, H., 2021. Scene understanding in construction and buildings using image processing methods: A comprehensive review and a case study. *Journal*

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