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# Emotional Maintenance: A Digital Model to Support Maintenance Decisions in Buildings' Coatings †

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**Abstract:** Maintenance decisions at the end of building components' service life are frequently driven by subjective motivations that can arise from various sources, including the building owner's personal preferences, sentimental attachments, aesthetic considerations, and individual/collective preferences or sense of taste. This study supports decision-making regarding maintenance actions by combining objective indicators of building degradation and subjective user perceptions to prioritize areas of focus, determine appropriate maintenance strategies, and allocate resources effectively.

**Keywords:** maintenance; digital model; automation of inspection; dwellers' feelings; rendered facades

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## 1. Introduction

Maintenance decisions at the end of building components' service lives are frequently driven by subjective motivations [1]. Subjective motivations can arise from various sources, including the building owner's personal preferences, sentimental attachments, aesthetic considerations, and individual/collective preferences or sense of taste [2]. It is important to acknowledge that subjective motivations for maintenance decisions, beyond technical requirements, hold value as they reflect the human element and emotional connections associated with buildings. Balancing these subjective motivations with technical considerations and financial constraints is essential for making well-informed decisions that address both practical needs and emotional connections. In this study, a digital model is proposed to assess the degradation state of buildings' coatings based on in situ inspections (using robotized platforms and a high-resolution camera) while engaging the building's occupants, tenants, or users to understand their perceptions, experiences, and concerns regarding the building's condition. A stains' detection algorithm, using multispectral analysis, is developed to identify the area affected by stains (a visible sign of degradation), which affect the facade's aesthetic appearance but also contribute to the worsening of other anomalies and consequent degradation and loss of properties of the coating.

## 2. Case Study—Bairro de Alvalade, in Lisbon, Portugal

The methodology was applied in Bairro de Alvalade, in Lisbon, Portugal, a neighborhood located in the northern part of the city. Alvalade is a neighborhood with a population of 30,000 people and an area of 5.34 square kilometers. The study was focused on three identical buildings with different conditions, named Buildings 4, 7, and 9 [3].

## 3. Final Digital Model

The methodology proposed includes three main steps: automatic evaluation of façades; a dwellers' feelings survey; and a final digital model. In the following sub-section, each of the steps is described, and the results are presented.

### *3.1. Automatic Evaluation of Façades*

First, a collection of images of the façades was acquired, tackling the advantages of using terrestrial robotic platforms to perform a planned survey [3]. Then, a mosaic image is computed to form the set of images acquired. Finally, an automatic identification of anomalies in facades through image classification is applied. In this case, a supervised classification is performed in MultiSpec [4], a multispectral image data analysis software. The images were loaded, and the users created classes by manually selecting specific areas on the image. Then, all of the building facades are classified into the different classes created at the pixel level [5,6].

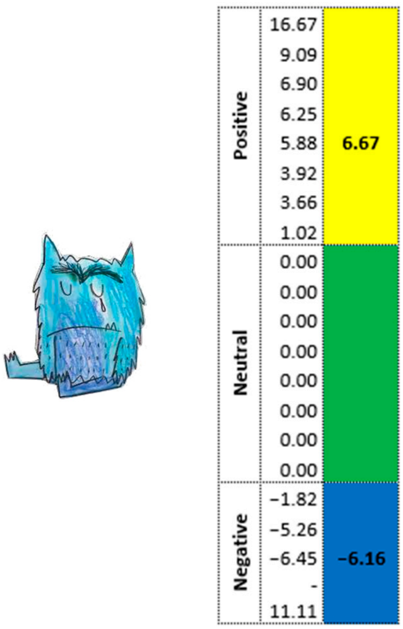
### *3.2. Dwellers' Feelings*

An opinion survey was conducted among the residents and neighbors of the Alvalade neighborhood to assess their perceptions of the degradation of façades. Twenty-five respondents, comprising fifteen men and ten women, ranging in age from 17 to 80 years (with an average age of 48 years), provided their impressions of the facade's condition in the three buildings.

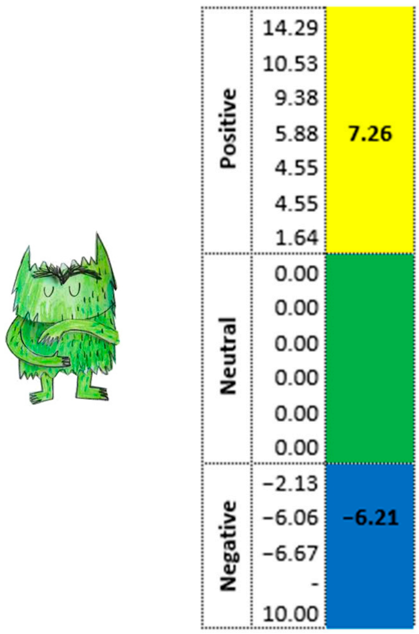
An analysis of these perceptions, 'ased'on the Vader analysis [7], was carried out to create acceptance profiles (Table 1). VADER gathers the sentiment scores linked to words from a lexicon and aggregates them to determine the score for sentences. The compound score is computed by summing the valence scores of individual words in the lexicon, with certain adjustments, and falls within a range from −33 (indicating highly negative sentiment) to +33 (reflecting strongly positive sentiment) [7,8].

**Table 1.** Dwellers' feelings.

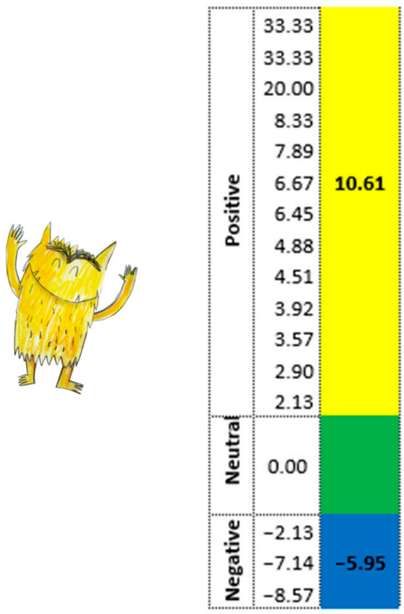
**Building 4**




**Building 7**



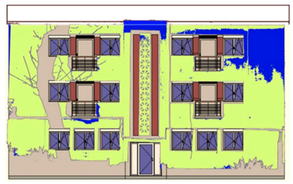
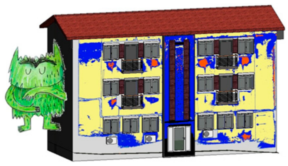
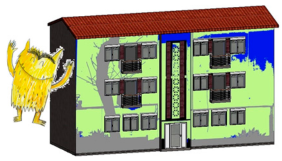

**Building 9**




### *3.3. Digital Model*

A digital model is assembled, combining the quantitative and qualitative data collected, reflecting the physical degradation condition and the dwellers' perceptions, respectively. This model can be used to perform a comprehensive diagnosis and, therefore, support maintenance decisions. The information on each façade processed, automatic inspection, and dwellers' feelings was merged into a 3D model and can be visualized, as exemplified in Table 2.

**Table 2.** Final digital model.

| | Building 4 | Building 7 | Building 9 |
|---|---|---|---|
| Automatic damage mapping |  |  |  |
| Final digital model |  |  |  |

## 4. Discussion of the Results

Building 4 exhibits the most extensive physical degradation on the façade's coating (Figure 1 and Table 2). This building received more negative and neutral reactions from the respondents regarding their assessment of the degradation state in comparison with the other two buildings. However, the differences between Building 4 and Building 9 are not as significant. Building 9, which is in better condition, received an overall less negative response, albeit with more neutral sentiments and less overall positive feelings. The results indicate that respondents can clearly identify the building in the worst condition, not having such a clear idea of the condition of the other two buildings.

(**a**) (**b**) (**c**)

**Figure 1.** Façades analyzed: (**a**) Building 4; (**b**) Building 7; (**c**) Building 9 (adapted from [1]).

## 5. Final Remarks

The methodology presented enables an emotional maintenance procedure for buildings through the development of a digital model that supports maintenance decisions on buildings' façades. The digital model allows identifying patterns, correlations, and discrepancies between objective degradation indicators and subjective user feedback. The dwellers' feelings are modeled based on onsite interviews to collect qualitative data on their observations and satisfaction levels. This study supports decision-making regarding maintenance actions by combining objective indicators of building degradation and subjective user perceptions to prioritize areas of focus, determine appropriate maintenance strategies, and allocate resources effectively.

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**Conflicts of Interest:** The authors declare no conflicts of interest. Author Nathália Olivo is currently employed by the company Deloitte but during the performance of the current study the author is a fellow of the project and was not employed in the company. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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