



PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE
ESCUELA DE INGENIERÍA

DEEP NEURAL NETWORK MODELS WITH EXPLAINABLE COMPONENTS FOR URBAN SPACE PERCEPTION.

ANDRÉS CÁDIZ VIDAL

Thesis submitted to the Office of Research and Graduate Studies
in partial fulfillment of the requirements for the degree of
Master of Science in Engineering

Advisor:
HANS LÖBEL

Santiago de Chile, July 2020

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*Gratefully to my parents and
siblings*

ACKNOWLEDGEMENTS

Write in a sober style your acknowledgements to those persons that contributed to the development and preparation of your thesis.

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ABSTRACT

The abstract must contain between 100 and 300 words. The abstract must be written in English and Spanish. In the case of doctoral theses, the layout of the abstract page is different, so please check the template provided by the OGRS.

Keywords: thesis template, document writing, (Write here the keywords relevant and strictly related to the topic of the thesis).

RESUMEN

El resumen debe contener entre 100 y 300 palabras. El resumen debe ser escrito en inglés y español. En el caso de tesis de doctorado, el formato de la página del resumen es distinta, por favor verifique la plantilla entregada por la Dirección de Postgrado.

Palabras Claves: plantilla de tesis, escritura de documentos, **(Colocar aquí las palabras claves relevantes y estrictamente relacionadas al tema de la tesis).**

1. INTRODUCTION

1.1. Thesis outline.

This work consists of seven chapters, first is this introduction, which shows the importance of both the automatic calculation of urban perception, and explainability in artificial intelligence, and ends with the hypothesis of this research. Chapter 2 is a detailed description of the research objectives. Chapter 3 consists of a summary of the relevant previous research. In chapter 4 the problem is formally defined and the proposed model is described. Chapter 5 gives details on model implementation and training. Finally, in chapter 6 and 7 consist of the results and conclusions of the research.

1.2. Importance of automatic urban perception

Urban perception is a feeling held by people about a location. These feelings can be and are often related to a particular characteristic, like happiness or beauty, or also inherently negative ones, like insecurity or fear (Ordonez & Berg, 2014).

The visual urban perception is responsible for a large parte of the experience that people go through while being at or using an urban space, this not only affects how much the spaces themselves are used (Khisty, 1994) but also the use of related means of transport (Antonakos, 1995). Other studies have also found correlations between urban perception, crime statistics (Ordonez & Berg, 2014) and wealth, and therefore used it as a proxy measure of inequality (Ordonez & Berg, 2014; Salesses, Schechtner, & Hidalgo, 2013; Rossetti, Lobel, Rocco, & Hurtubia, 2019).

On the other hand, being able to understand a community's need and perception of a city at scale is something of key importance on developing cities, in order for the limited resources of local governments to be applied appropriately (Santani, Ruiz-Correa, &

Gatica-Perez, 2018), but traditional methods for the measuring of urban perception, consist of hand made polls about specific locations making it a extremely costly and hard to escalate process (Clifton & Ewing, 2008).

Considering these facts, automatic estimation of urban perception at great scales becomes a very relevant research problem, because the generated data would be a powerful tool to guide the improvement of public spaces and the design of public policy.

1.3. Importance of explainability in deep learning.

Currently, thanks to the great volumes of data generated by web platforms (Salesses et al., 2013) and to modern deep learning techniques (LeCun, Bengio, & Hinton, 2015), the problem of estimating urban perception has become feasible, and some previous studies have achieved relevant results (Dubey, Naik, Parikh, Raskar, & Hidalgo, 2016; Rossetti et al., 2019).

However, current deep learning methodologies, have the disadvantage of being "black boxes", in other words, they lack a direct or systematic way to explain or interpret the obtained results. This problems comes from the end to end nature of the neural network models and from the millions of learnable parameters they contain. Many of the problems in which these models are used would greatly benefit of more human understandable explanations of the results, making this a very important area of research for the deep learning field (Adadi & Berrada, 2018). Current research in this matter is primarily moving in two directions: one is to design novel neural network architectures and training methods so the models are more interpretable, such as the work by Dong, Su, Zhu, and Zhang (2017), the other direction is to create post-hoc algorithms (Adadi & Berrada, 2018) that analyze the results given by the neural network, these algorithms sometimes use other machine learning models, including neural networks, such as the work by Ghorbani, Wexler, Zou, and Kim (2019).

For the particular case of urban perception, explainability of the results is highly relevant, since the added information is valuable for the design of public policy, for example, it could be use to better discriminate which locations would be better recipients of an intervention, and which elements to modify so it convenes an effective improvement of perception

1.4. Thesis Hypothesis

The hypothesis of this work, is that a more explainable, yet similarly accurate deep learning model for estimation of urban perception can be obtained, by changing traditional network components for others that are more semantic. This model must be end-to-end trainable and provide additional information that can have human interpretation.

2. OBJECTIVES

The thesis main objectives are the following:

- (i) Design and train a neural network architecture for the urban perception problem, with close accuracy to previous architectures, but with explainable results up to the instance level.
- (ii) Design an end-to-end learning scheme for the chosen architecture.

The secondary objectives are:

- (i) Make and aggregated analysis and interpretation of the results generated by the model.
- (ii) Study an example of the trade of between accuracy and explainability in machine learning.

3. RELATED WORK

This are some related investigations.

4. PROPOSED ARCHITECTURE

4.1. Problem Definition

4.2. Network architecture

4.3. Loss function

5. METHODOLOGY

5.1. Implementation

5.2. Training

6. RESULTS

7. CONCLUSIONS

Nothing to say. Be happy.

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APPENDIX

A. FIRST APPENDIX