PHD TITLE

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Colophon This document was typeset in LaTeX, using the beautiful `tufte-latex` class[1] and a hand-made overlay inspired by Aaron Turon's thesis *Understanding and expressing scalable concurrency* and Marie-Morgane Paumard's thesis, *Solving jigsaw puzzles with deep learning*. Firmin Didot's `GFS Didot` acts as the typeface. The bibliography is typeset using `biblatex`.

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First printing, Month Year

Acknowledgments

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Résumé

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Keywords A, AA, AAA, AAAA.

Abstract

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Keywords A, AA, AAA, AAAA.

Publications

This dissertation draws heavily on earlier work and writing in the following papers:

Journals

- [PPT20] Marie-Morgane Paumard, David Picard, and Hedi Tabia (2019). Deepzzle: Solving Visual Jigsaw Puzzles with Deep Learning. In IEEE Transactions on Image Processing (TIP);
- Marie-Morgane Paumard (2020). Remonter un site archéologique à partir de fragments : cas du sanctuaire des Vaux de la Celle (fr). In Technè (forthcoming publications);

Refereed conferences

- Marie-Morgane Paumard, David Picard, and Hedi Tabia (2020). Solving Jigsaw Puzzle with Deep Monte-Carlo Tree Search. In submission;
- [PPT18a] Marie-Morgane Paumard, David Picard, and Hedi Tabia (2018). Image Reassembly Combining Deep Learning and Shortest Path Problem. In Proceedings of the European Conference on Computer Vision (ECCV);
- [PPT18b] Marie-Morgane Paumard, David Picard, and Hedi Tabia (2018). Jigsaw Puzzle Solving Using Local Feature Co-Occurrences in Deep Neural Networks. In Proceedings of the IEEE International Conference on Image Processing (ICIP);

Non-refereed conference

- Marie-Morgane Paumard, David Picard, and Hedi Tabia (2019). L'apprentissage profond pour le réassemblage d'images patrimoniales (fr). In proceedings of the *Colloque francophone de traitement du signal et des images* (GRETSI).

Contents

List of Artworks

List of Figures

List of Tables

List of Terms and Acronyms

GLOSSARY

Reassembly (a ~) Any output of a puzzle-solving algorithm. 5

ACRONYMS

MET Metropolitan Museum of Art. 5

Part I

PROLOGUE

1

Introduction

?? ➤

1.1 CONTEXT

Welcome to this thesis template :) You can use it as you want: you are not obliged to mention this template, but it would be nice to do so (e.g., keep the colophon).

1.2 MAIN CONTRIBUTIONS

This dissertation aims to .... To that end, we design two algorithms:

1.2.1 *First part name*

MTH1 introduction ...
Our contribution includes:

- First itemtext
- Second itemtext

In the rest of this dissertation, we refer to this method as MTH1.

1.2.2 *Second part name*

Idem

1.2.3 *Other contributions*

Our other contribution includes:

- First itemtext
- Second itemtext

1.3 ORGANIZATION OF THE DISSERTATION

Chapter 2 presents some typography tips.

The rest of the dissertation is composed of the two proposed approaches:

Part name

Chapter 3 is an example of state of the art chapter.

Chapter 4 describes the equation and algorithms.

Chapter 5 walks through figures and tables.

Part name

Chapter 6 presents an empty state of the art.

Finally, the dissertation concludes with Chapter 7, which summarizes the contributions and suggests a few additional research ideas.

General appendices

Appendix A is an introduction to deep learning.

Artwork 1: *Two Men Contemplating the Moon*, Caspar David Friedrich, ca. 1825-30, from the MET Open Collections.

2

Typography

◂ Chapter 1 Chapter 3 ▸

Synopsis This chapter presents some typographical specificities of the model §2.1. Last, it presents some type of lists §??.

2.1 Some hints on typography

2.1.1 *Numbers*

For numbers, you can use oldstylenums: 16,000 versus 16,000; 2nd century versus 2nd century.

2.1.2 *Notes*

You can use either margin notes or footnotes[1].

You can change the position of a note (see code)[2].

Margin notes have no number.

[1] *Footnotes* have a number.

[2] **A footnote that is 5em lower.**

2.1.3 *Types of paragraphs*

Here is a first paragraph. You can create a new paragraph as usual:

And the new paragraph will start this way. An alternative is to call the newthough command:

A new thought starts here. As you can see, the beginning of the paragraph is different. You can of course use an empty newthough:

And it will looks that way. Last, you can use the paragraph command:

A new paragraph.

2.1.4 *Acronyms*

Here is an acronym:

- With acrshort command: MET;
- With acrfull command: Metropolitan Museum of Art (MET);
- With acrlong command: Metropolitan Museum of Art.

Here is a term for the glossary: Reassembly. Use gls, Gls, glspl, etc. commands.

2.2 LISTS

2.2.1 *Description list*

By the way, you can use a marginfigure inside a list.

Fragments shape: text

Fragments quantity: text

Binding puzzle sizes: text

Figure 2.1: Example of input in the case the position is known but the rotation is unknown. © A.C. Gallagher [Gal12].

2.2.2 *Bullet list*

- archaeology;
- cryptography;
- forensic medicine;
- genome biology;
- medicine.

Part II

FIRST METHOD

3

State of the art

◂ ?? Chapter 4 ▸

Synopsis This chapter introduces ... We introduce the types of ... in §5.1, and we detail each of them in §3.2-3.3.

3.1 Introduction

... Another line of comparison emerged through state of the art, concerning the objective of the neural networks, which can either be:

Permutation: Given all the fragments, the neural network predicts a permutation that gives a correct reassembly (§3.2);

Pairwise comparison: The neural network predicts the position of a fragment in relation to another fragment (§3.3).

3.2 Permutations

... section intro ...

Noroozi and Favaro[1] solve Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

[1] [NF16] M. Noroozi and P. Favaro, Unsupervised learning of visual representations by solving jigsaw puzzles.

Santa Cruz et al.[2] propose an architecture that Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi

[2] [SCFCG17] R. Santa Cruz et al., DeepPermNet: Visual Permutation Learning.

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Figure 3.1: Example of permutation task with inpainting and colorization. © Kim et al. [KCYK18].

Kim et al.[3] tackle the case of Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

[3] [KCYK18] D. Kim et al., Learning Image Representations by Completing Damaged Jigsaw Puzzles.

Wei et al.[4] Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

[4] [WXR+19] C. Wei et al., Iterative Reorganization with Weak Spatial Constraints: Solving Arbitrary Jigsaw Puzzles for Unsupervised Representation Learning.

3.3 PAIRWISE COMPARISON

... section intro ...

4

Method 1

◂ Chapter 3 Chapter 5 ▸

Synopsis This chapter explains MTH1, ...

4.1 Introduction

In this chapter, we present MTH1, which ...

Figure 4.1: A task submitted to MTH1.

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Sources We walk through the following articles, presenting most of our contributions[1]:

[1] The results are discussed in Chapter 5.

- *Jigsaw Puzzle Solving Using Local Feature Co-Occurrences in Deep Neural Networks*;
- *Image Reassembly Combining Deep Learning and Shortest Path Problem*;
- *Deepzzle: Solving Visual Jigsaw Puzzles with Deep Learning*.

4.2 METHOD OVERVIEW

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Our method addresses the following settings:

- First itemtext
- Second itemtext
- Last itemtext
- First itemtext
- Second itemtext

We also ...

4.3 PROBLEM FORMULATION

Summary Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

NOTATIONS We introduce ... .

Here is an equation without label:

$$\max P_r(x_c, x_{1,1}, x_{1,2}, \dots, x_{2,j_1}, \dots, x_{f,p}).$$

Here an equation with label:

$$\max P_r(x_c, x_1, x_2, \dots, x_f). \tag{4.1}$$

4.4 ALGORITHMS

Algorithm 1 presents the outline of the greedy solver:

```
1: procedure GREEDY(Y)
2:     reassembly ← [0] × 8
3:     while 0 ∈ reassembly or Y ≠ ∅ do
4:         max_frag, max_pos ← argmax(Y)
5:         reassembly[max_pos] ← max_frag
6:         Y.pop_row(max_frag)
7:         Y.pop_column(max_pos)
8:     end while
9:     return reassembly
10: end procedure
```

Algorithm 1: Greedy algorithm outline.

where Y is ...

5

Mth1's results

◂ Chapter 4 Chapter 6 ▸

Synopsis This chapter presents the results we obtained with METHOD1. We start with ... §5.1, and we continue with ... §5.2.

5.1 sec1

This section compares ...

5.1.1 *Figures examples*

Single figure Figure 5.1 shows ... Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

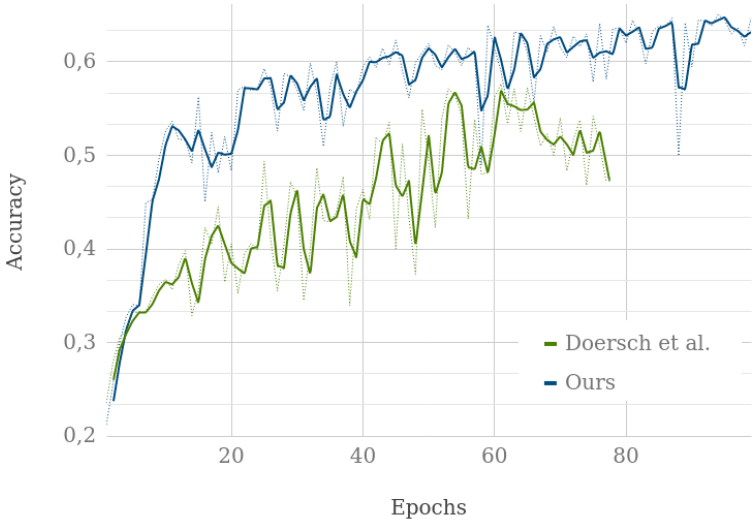

Figure 5.1: Validation accuracy scores — Comparison of our architecture and Doersch et al.'s.

Double figure Figure 5.2 shows ... Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

(a) (b)

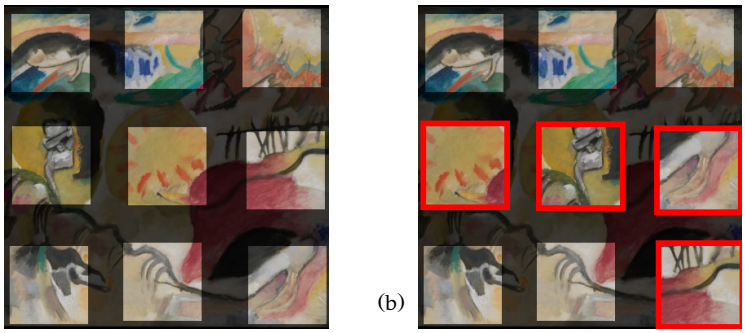

Figure 5.2: Example of a wrong reassembly with unknown center. The red outline shows the fragments that are misplaced — Fig. (a) shows the expected outcome, and Fig. (b) the predicted result.

Margin figure Figure 5.3 illustrates ... Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

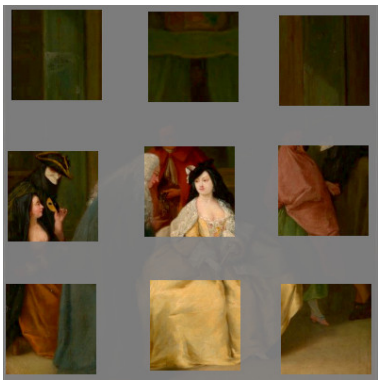

Figure 5.3: A typical reassembly.

Full width figure Figure 5.4 shows ... Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

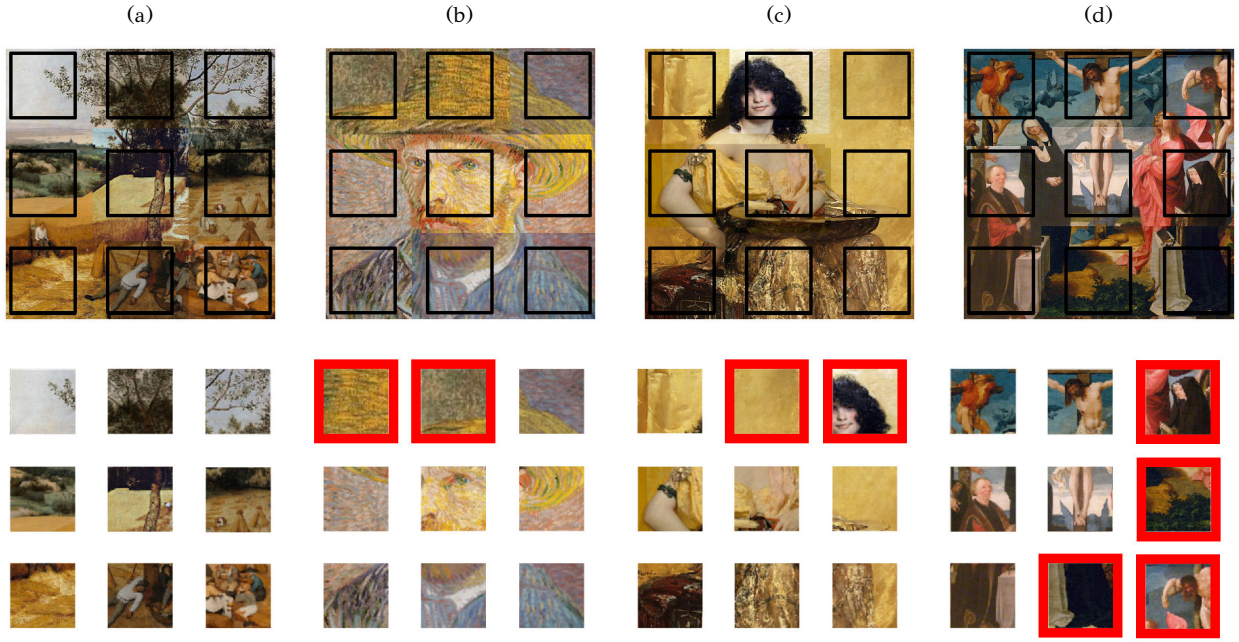

Figure 5.4: Reassemblies from patchwork images. The first row shows the patchwork images from which the fragments were extracted. The second row displays the reassemblies for the patchwork fragments. The third row contains the reassemblies of the MET image (without patchwork). The red outline shows the fragments that are misplaced.

5.1.2 *Tables examples*

Table 5.1 compares ... Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

A	B	C
-	-	-

Table 5.1: Validation accuracy scores — Comparison between the setups.

Table 5.2 shows ... Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet

aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

	Best attempt		Worst attempt		
Number of attempt	Fragment-wise (%)	Puzzle-wise (%)	Fragment-wise (%)	Puzzle-wise (%)	Reassemblies done in 24h
-	-	-	-	-	-

Table 5.2: Reassembly scores — Impact of the order of fragments.

5.2 SEC2

This section ...

Part III

SECOND METHOD

6

State of the art

◂ ?? Chapter 7 ▸

Synopsis This chapter presents ...

6.1 Introduction

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Part IV

EPILOGUE

7

Conclusion

◂ Chapter 6 Appendix A ▸

7.1 LOOKING BACK

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7.2 LOOKING AHEAD

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"Citation"
– Author, *Book*

Artwork 2: *Landscape with Stars*, Henri-Edmond Delacroix, ca. 1905, from the MET Open Collections.

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Part V

GENERAL APPENDIX

A

Introduction to deep learning

◂ Chapter 7 Appendix B ▸

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Part VI

TECHNICAL APPENDIX

B

On the graphs sizes

◂ Appendix A

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