Contents

List of Figures xv

List of Tables xvii

1 Introduction 1
- 1.1 Motivation . . . 3
- 1.2 Objectives . . . 10
- 1.3 Framework . . . 11
- 1.4 Outline . . . 12

2 Embryology and the embryo 13
- 2.1 Embryo development . . . 15
- 2.2 Morphology assessment of the embryo . . . 18
- 2.3 Chromosomal anomalies and preimplantation genetic testing . . . 24
- 2.4 Time-lapse incubators . . . 26

3 Automation of embryo evaluation with transfer learning techniques 31
- 3.1 Background and Motivation . . . 33
- 3.2 Material . . . 35
- 3.3 Method . . . 37
  - 3.3.1 Convolutional Neural Networks . . . 38
  - 3.3.2 Transfer Learning Approach . . . 42
  - 3.3.3 Hyperparameters . . . 43
- 3.4 Results . . . 45
- 3.5 Discussion and Conclusions . . . 46

4 Viability and quality assessment with supervised contrastive and inductive transfer leaning. 51
- 4.1 Background and Motivation . . . 53
- 4.2 Material . . . 55

4.3 Methods . . . 57
4.3.1 Supervised contrastive learning for viability embryo characterization . . . 57
4.3.2 Inductive transfer learning for quality embryo prediction . 61
4.4 Ablation experiments . . . 61
4.4.1 Supervised contrastive learning settings . . . 61
4.4.2 Inductive transfer learning configuration . . . 64
4.5 Results . . . 65
4.5.1 Viability prediction . . . 65
4.5.2 Quality prediction . . . 68
4.6 Discussion and Conclusions . . . 68

5 Ploidy status prediction with long short-term memory cells 75
5.1 Background and Motivation . . . 77
5.2 Material . . . 79
5.3 Method . . . 80
5.3.1 Recurrent neural network . . . 80
5.3.2 Spacio-temporal approach . . . 86
5.3.3 Experiments . . . 89
5.4 Results . . . 89
5.4.1 Quantitative results . . . 89
5.4.2 Qualitative results . . . 91
5.5 Discussion and Conclusions . . . 92

6 Segmentation of blastocyst structures for GERI incubator images. 97
6.1 Background and Motivation . . . 99
6.2 Material . . . 101
6.3 Method . . . 102
6.3.1 Encoder-decoder architecture . . . 102
6.3.2 U-Net . . . 104
6.3.3 Dice loss function . . . 106
6.3.4 Experiments . . . 107
6.3.5 Post-processing . . . 109
6.4 Results . . . 111
6.5 Discussion and Conclusions . . . 113

7 Final conclusions 117
7.1 Global remarks . . . 119
7.2 Specific remarks . . . 119
7.3 Future work . . . 121

Merits **122**

Bibliography **127**