

# Contents

<b>List of Figures</b>	<b>vi</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	1
1.2 Hypotheses . . . . .	2
1.3 Objectives . . . . .	2
1.3.1 Main Objectives . . . . .	2
1.3.2 Specific Objectives . . . . .	2
1.4 Thesis Structure . . . . .	3
<b>2 Scanpath Ocular</b>	<b>4</b>
2.1 Eye Movements . . . . .	4
2.2 Brain Selection . . . . .	5
2.3 Spatial Selection . . . . .	5
2.4 Fixation Duration . . . . .	6
2.5 Saliency and Selective Order . . . . .	6
2.6 Calculating saliency . . . . .	6
2.7 Fovea centralis . . . . .	8
2.8 Scanpath Comparison Metrics . . . . .	9
<b>3 Theoretical background for Scanpath Prediction</b>	<b>12</b>
3.1 Models for Scanpath Prediction . . . . .	12
3.2 Summary of Artificial Neural Models . . . . .	13
3.2.1 Theoretical definition . . . . .	14
3.2.2 Supervised Learning . . . . .	15
3.2.2.1 Stochastic Gradient Descent . . . . .	15
3.2.2.2 Backpropagation . . . . .	17
3.2.3 Neural networks . . . . .	17
3.2.3.1 Convolutional neural network . . . . .	17
3.2.3.2 Recurrent neural network . . . . .	18
3.2.3.3 Attention neural network . . . . .	20
3.2.4 Regularization methods . . . . .	21
3.2.4.1 Dropout . . . . .	21
3.2.4.2 Early stop . . . . .	21
3.3 Auto-regressive models for multi-step-ahead forecast in time series . . . . .	22
3.3.1 Recursive forecast . . . . .	22
3.3.1.1 Training phase . . . . .	22

3.3.1.2	Inference . . . . .	23
3.3.2	Direct forecast . . . . .	24
3.3.3	Forecast strategy selection . . . . .	24
3.4	Modelling uncertainty via MC-Dropout . . . . .	25
3.4.1	Approximate Variational Inference . . . . .	25
<b>4</b>	<b>Applications of Artificial Neural Networks for Scanpath Prediction</b>	<b>27</b>
4.1	Methods . . . . .	28
4.1.1	Dataset . . . . .	28
4.1.2	Modelling Procedure . . . . .	29
4.2	Modelling scanpath with a recurrent neural model using positional information . . . . .	31
4.2.1	Positional Scanpath and LSTM model . . . . .	31
4.2.2	Analysis of PosScan model . . . . .	32
4.2.2.1	PosScan results grouped by train image type . . . . .	33
4.2.2.2	PosScan results grouped by predicted image type . . . . .	41
4.2.2.3	Prediction in other subjects rather than the trained one . . . . .	46
4.2.3	Remarks . . . . .	49
4.3	Selecting features to enhance the model . . . . .	50
4.4	Modelling scanpath with an attention neural model using positional and spatial information though time . . . . .	55
4.4.1	Saliency maps from foveated images and Attention model . . . . .	55
4.4.2	Analysis of FovSOS-FS model . . . . .	57
4.4.2.1	FovSOS-FS results grouped by predicted image type . . . . .	58
4.4.3	Analysis of FovSOS-FSD . . . . .	62
4.4.3.1	FovSOS-FSD results grouped by train image . . . . .	63
4.4.3.2	FovSOS-FSD results grouped by predicted image . . . . .	66
4.4.4	Remarks . . . . .	69
4.5	Comparative discussion of models . . . . .	69
<b>5</b>	<b>Conclusions and Future Work</b>	<b>74</b>
	<b>Bibliography</b>	<b>77</b>
	<b>ANNEXES</b>	<b>86</b>
	<b>Annexed A PosScan architecture</b>	<b>87</b>
A.1	Architecture parameters . . . . .	87
A.2	Metric results grouped by train image type . . . . .	88
A.3	Metric results grouped by predicted image type . . . . .	92
	<b>Annexed B FovSOS-FS architecture</b>	<b>96</b>
B.1	Architecture parameters . . . . .	96
B.2	Metric results grouped by predicted image type . . . . .	97
	<b>Annexed C FovSOS-FSD architecture</b>	<b>101</b>
C.1	Architecture parameters . . . . .	101
C.2	Metric results grouped by train image type . . . . .	102
C.3	Metric results grouped by predicted image type . . . . .	106