List of Figures

Figure	Title	page
1.1	Organization of Thesis	4
2.1	a) Outline contour of a walking subject and their corresponding dot configuration b) motion paths of seven side joints of the walking person (reprinted from [Johansson [1973]]© Springer, 1973)	11
2.2	3-D model description of humans using cylindrical parts (reprinted from [Marr and Nishihara [1978]] © The Royal Society, 1978)	11
2.3	a) Kinect camera with its camera configuration b) Pose estimation using a depth camera (reprinted from [Shotton <i>et al.</i> [2013]] © IEEE, 2013). Body part label at each pixel is	
2.4	predicted using Body part classification (BPC) and used to localize joints Mixture-of-parts model [Yang and Ramanan [2011]; Felzenszwalb and Huttenlocher [2005]]; in the top-right model a single template is warped to different orientations. In the bottom-right, the body parts are Approximated using small warps by translating patches connected	12
2.5	with a spring (reprinted from [Yang and Ramanan [2011]] © IEEE, 2011) Mesh feature (reprinted from [Yamato <i>et al.</i> [1992a]] © IEEE, 1992), sample shape masks	13
	for foreground stroke from tennis	15
2.6	Sample MEI and MHI images (reprinted from [Bobick and Davis [2001]] © IEEE, 2001)	15
2.7 2.8	Stacked silhouettes from action frames (reprinted from [Blank et al. [2005]], © IEEE, 2007) a)Shape context feature for human representation (reprinted from [Belongie et al. [2002]], © IEEE, 2002), b)matrix representation of shape context. Beference silhouette	15
2.9	with 2 query silhouettes Space time interest point features for a walking sequence (reprinted from [Laptev	16
	[2005a]], © Springer, 2005)	16
2.10	2D vs 3D convnet models (reprinted from [Tran <i>et al.</i> [2015]], © IEEE, 2015)	17
2.11	3D pseudo resnet : an alternate to 3D convolution with separate spatial and temporal filters (reprinted from [Qiu <i>et al.</i> [2017]], © IEEE, 2017)	18
4.1	Sun Salutation Sequence	32
4.2	Timeline illustrating jerks, rest times and consistency. From top to bottom sequence 1) 2 cycles of fast Sun Salutation by Yoga expert with no jerk, no rests, and consistent action. 2) 1 cycle of slow Sun Salutation by Yoga expert without jerk and uniform rest times 3) 1 cycle of slow Sun Salutation with jerk and non-uniform rest times 4) 2 cycles of inconsistent Sun Salutation with jerks.	33
4.3	Mesh features for a posture of Sun Salutation	34
4.4	Sample frames of Sun Salutation with variable no. of STIP features	35
4.5	Concatenated Hidden Markov Model for long-term action sequence	37
4.6	Block Diagram for Fast/Slow Sun Salutation decoding	37
4.7	Key poses of Action 4 and 7; Red arrows indicate motion direction of body parts	38
4.8	Activity graph of a Sun Salutation sequence	40
4.9	Illustration of false alarms and missed anomaly detections	42
5.1	Pose-vector representation	46
5.2	Approximate String Matching illustration	47

5.3	DTW alignment: (a) with missed actions (b) anomalous actions	49
5.4	Misalignments due to Dynamic Time Warping	49
5.5	Anomalous Poses in Amateur Videos	50
5.6	False Alarm for anomalous segments due to incorrect pose estimation	51
6.1	Sequence-to-Sequence Autoencoder model to learn temporal evolution of expert videos	54
6.2	Scoring of Test Sequences	56
6.3	Rank correlation of individual template videos	57
6.4	Reconstruction Results on some sample videos. Top to Bottom: First bar shows the	
	ground truth sun salutation sequence followed by five test sequences and their respective	
	reconstructed videos. Different actions are missed in different videos. The reconstructed	
	sequence matches the ground truth sequence in every case.(Different colors denote	
	different poses. Black color denotes padding used to generate fixed length video)	58
7.1	Our community detection based segmentation technique is unsupervised and requires	
	no training and can segment without knowledge of count of action categories	62
7.2	Analysis of community detection results for video dataset	65
7.3	a) Shape context feature for Weizmann dataset human silhouette b) MHAD101-s human motion skeletal data	67
7.4	Qualitative segmentation results where GT : Ground Truth: Different colors correspond	07
7.1	to distinct actions	68
7.5	Comparative results for all videos	68
7.6	Anomalous pose detection result	69
, 7,7	Incorrect sequences of the dataset: A denotes the anomalous actions	70
7.8	Segmentation results : GT refers to the ground truth: different colors represent different	,
	poses; Gray color indicates transition frames between the key poses	71
8.1	Siamese Architecture for Deep Metric Learning	77
8.2	Score Estimation Relative to Expert	78
8.3	Clip level similarity Estimation for evaluating individual clip contribution	80
8.4	Architecture variations	84
8.5	Shows the t-SNE plots of LSTM embedding and Siamese embedding of training and	
	test data. Column 1 represents the distribution of embeddings of all the data points	
	with different colours of different dive types. Columns 2,3,4 represent the score-wise	
	distribution of 3 distinct dive types where the radii of the circles drawn are proportionate	
	to the score of the corresponding embedding. Row1 shows the plots of the LSTM embedding	
	O_q . Subsequent rows show Siamese embeddings at D_2 with different reference biases	
	used at O_p . Row2 shows the plots when using a Uniform Bias at O_p . Rows 3, 4 and 5	
	show plots with dive type specific biases applied at O_p . Row3 uses the worst performer	
	bias, Row4 uses the 50 percentile score performer bias, Row5 uses the 75 percentile	
	score performer bias and Row6 uses the expert bias.	90