Crowd analysis using visual and non-visual sensors, a survey

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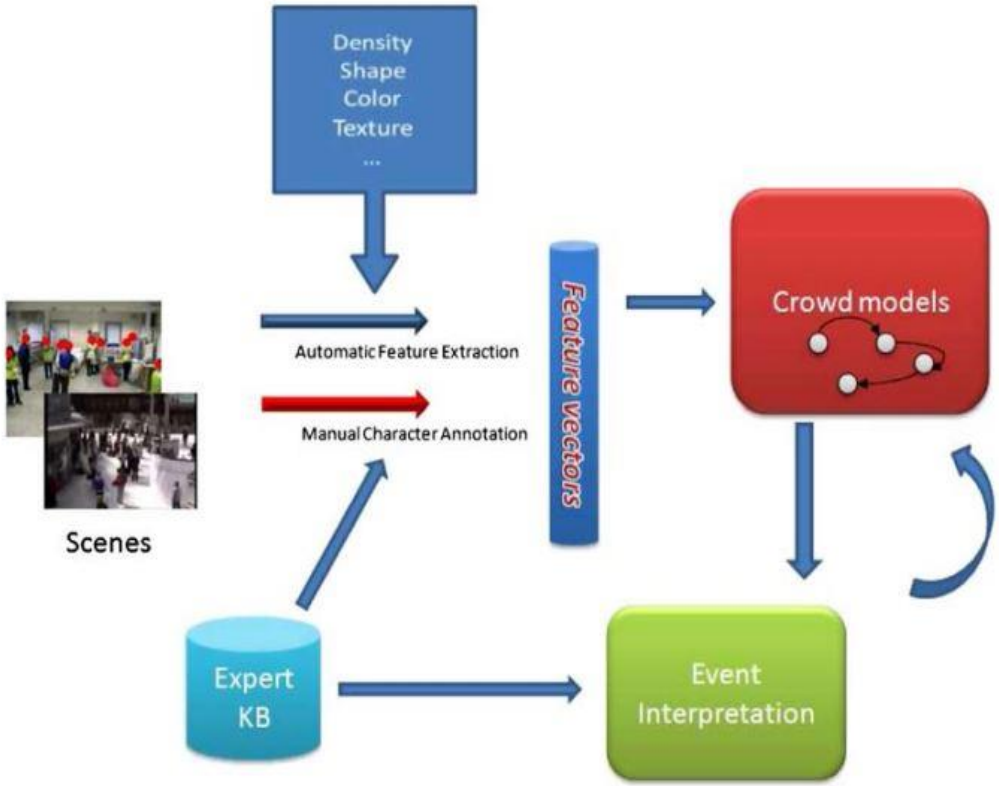
Introduction

- Public places like railway stations, airports, music concerts halls and shopping centers etc. are characterized by huge number of people called **crowd**.
- In dense crowds, any **abnormal behavior** or incident could lead to severe undesirable events.
- **Stampede** at " Love Parade music festival in Germany in 2010".

Motivation

- The larger the scale of the crowd becomes, the harder the **visual surveillance** is for the human eye.
- Automatic systems can assist human operators in **detecting and localizing abnormal events** within crowds.
- Considerable research has been made by signal processing community but **occlusions, clutter and uncalibrated** cameras still represent open problems.
- Recently, **non-visual information** based systems have got particular interest as it has some advantages over computer vision based techniques.
- Some issues with non-visual based information is **privacy, participation and data set availability**.
- **Fusion** of both, visual and non-visual information could lead this research area to better solutions in crowd analysis

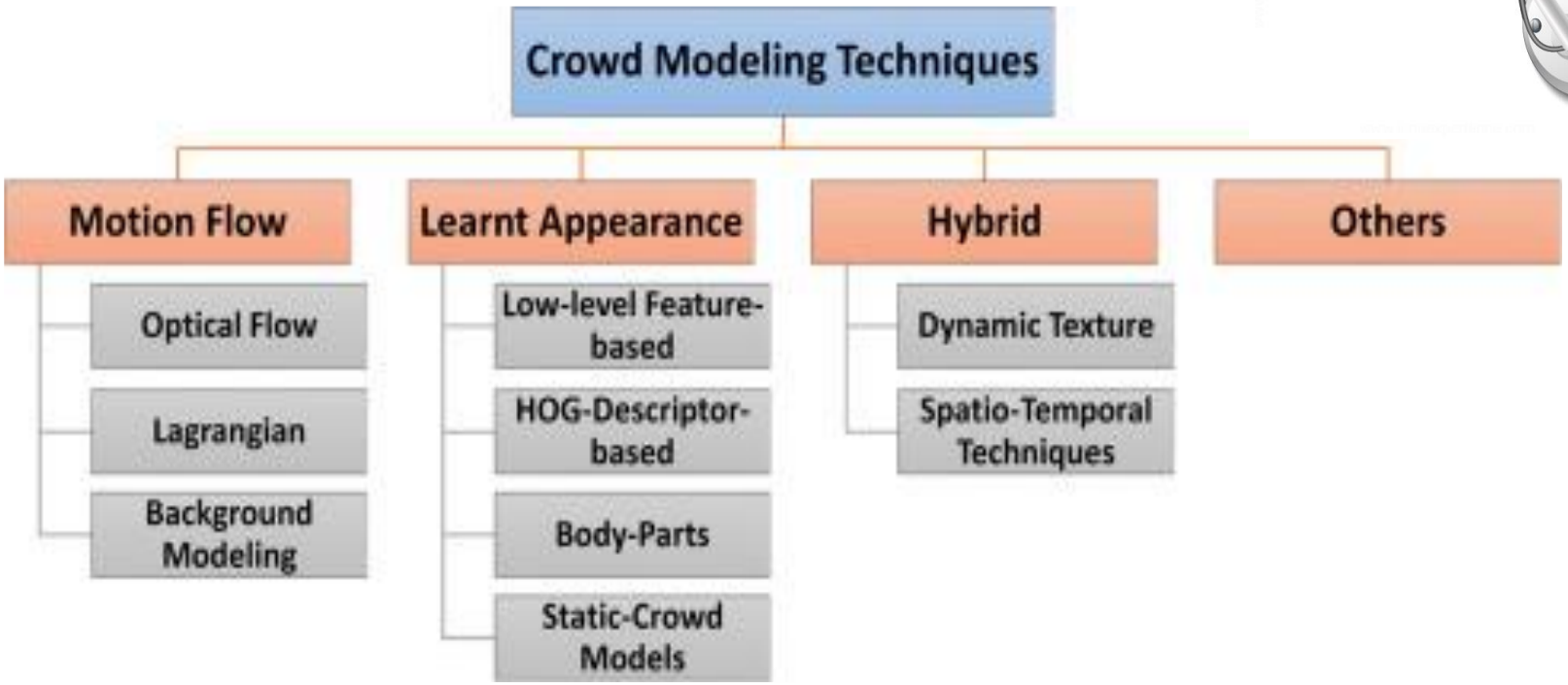
A framework for crowd analysis



Current state of the art

VISUAL AND NON-VISUAL

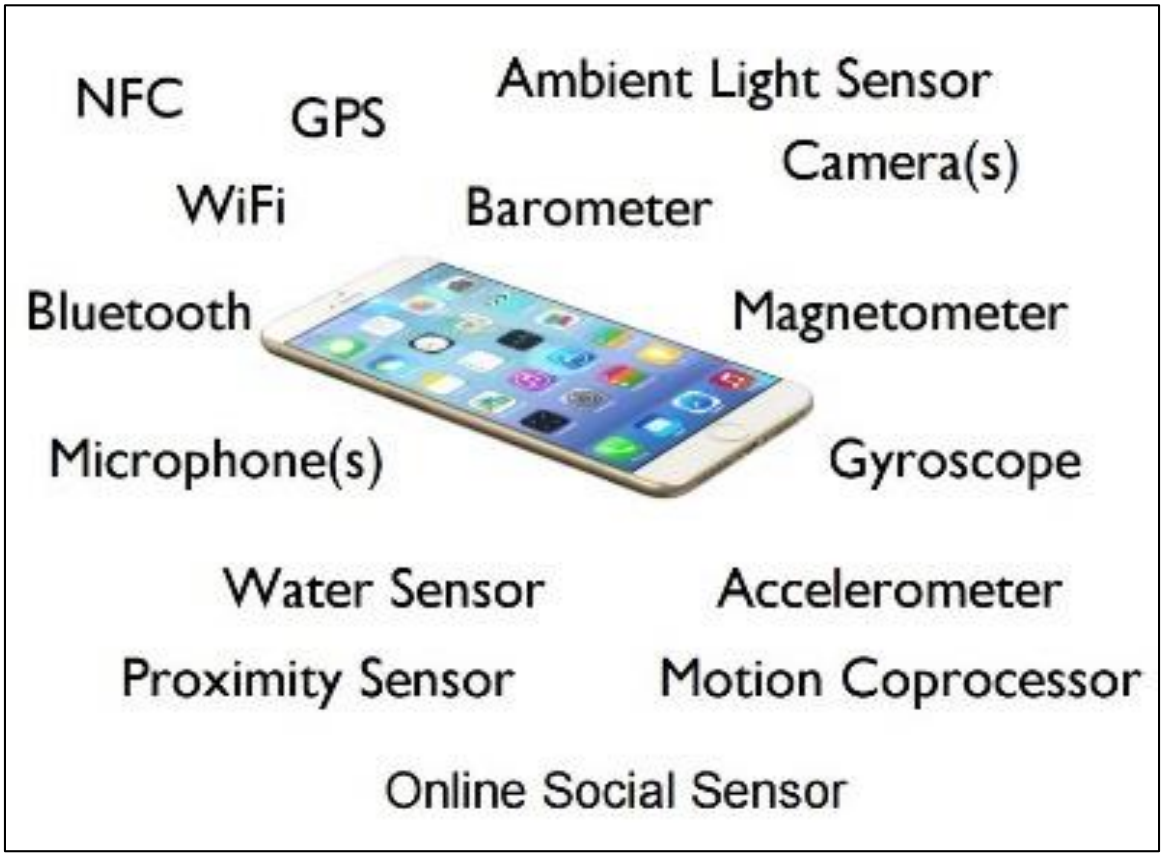
VISUAL SYSTEMS



M. S. Zitouni, H. Bhaskar, J. Dias, and ME Al-Mualla, “Advances and trends in visual crowd analysis: A systematic survey and evaluation of crowd modelling techniques,” Neurocomputing, vol. 186, pp. 139–159, 2016

Non-visual system

The smart phones are equipped with an impressive array of sensors

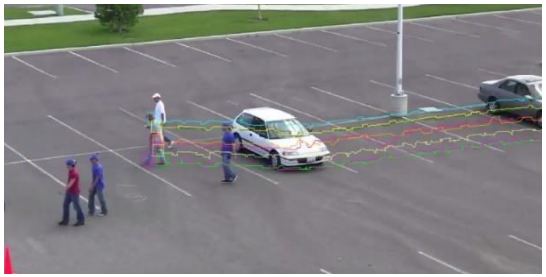


Mobile sensing

- Smart phones can be used for collective sensing called mobile crowd sensing.
- Mobile sensing based systems are recent trends in the crowd analysis research.
- Mobile crowd sensing refers to the wide variety of sensing models in which users with sensing and computing devices collect and contribute to required data for different applications like object tracking, counting, behaviour analysis and anomaly detection.

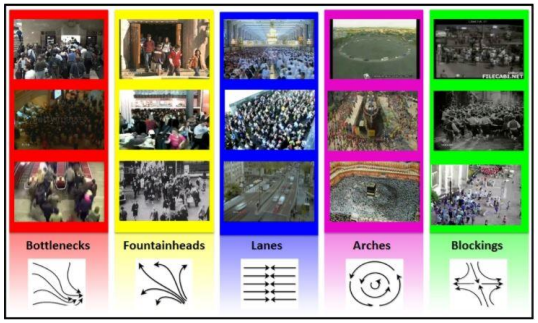
Applications

Tracking



Density estimation/Counting

Behavior Recognition



Anomaly Detection

Incentives

- Participation avoidance.
- Provision of incentives.
  - Entertainment as incentives
    - Treasure game (Virtual coins earned looking for signals)
  - Service as incentives
    - Google traffic
  - Money As Incentives
    - Mobile Games

L. G. Jaimes, I. J. Vergara-Laurens and A. Raij, "A Survey of Incentive Techniques for Mobile Crowd Sensing," in *IEEE Internet of Things Journal*, vol. 2, no. 5, pp. 370-380, Oct. 2015.

Privacy issues

- The most crucial aspect in the mobile crowd sensing systems.
- Users usually refuse to share their personal data.
- For personal safety, people often accept to share their personal data.
  - E-bracelets for Hajj pilgrims Saudi Arabia.

Tools and datasets

- Choices of datasets are the key components for a systematic evaluation of methods in crowd analysis.
- Visual datasets are frequently available.
  - Examples include UCSD, PET, UCF, CAVIAR, and UMN etc.
- In mobile crowd sensing datasets have been a major issue.
  - CROWDSIGNALS.IO
  - Building the Community's Largest Labelled Mobile and Sensor Dataset

Comparative analysis

- Crowd scenes may be structured and unstructured depending upon the crowd dynamics.
- Structured crowds have a structured flow of motions in a scene and vice versa.
- Gap increases when it comes to global or local level analysis.
- Network* and on-device based localizations.

T. Couronne, A-M. O. Raimond, and Z. Smoreda, “Looking at spatiotemporal city dynamics through mobile phone lenses,” in 2011 International Conference on the Network of the Future, 2011

Detection/tracking

Sensor modality	Scope	Technique	Structured	Unstructured	References
Visual	Holistic	Optical Flow	✓		K. Barbara 2012
		Dominant Motions	✓	✓	A. M. Cheriyadat 2008
		Dominant Motions	✓		O. Ozturk 2010
	Individual	Energy Function		✓	M. Rodriguez 2011
		Hierarchical Clustering		✓	W. Ge 2012
		Synthetic Aperture Imaging	✓		T. Yang 2013
		Bayesian Approach	✓		M. Butenuth 2011
		Social Force Model		✓	R. Mazzon 2013
Non-Visual	Network	Bandwidth usage	✓	✓	F. Calabrese 2011
	On-device	GruMon	✓		R. Sen 2014
		Tracking	✓	✓	M. Wirz 2013
		Data Fusion+ clustering	✓	✓	M.B. Kjaergaard 2012

Counting/density estimation

Sensor modality	Scope	Technique	Structured	Unstructured	References
Visual	Holistic	Velocity Estimation	✓		Y. Cong 2009
		Pixel Count	✓	✓	R. Ma 2004
		Machine Learning + Thresholding	✓		B. Yogameena 2012
		Linear Regression	✓		G. Garcia 2012
		RGB Plus Depth	✓	✓	H. Fu 2012
		Optical Flow	✓		K. Barbara 2012
	Individual	Detection Flow	✓		J. Xing 2011
Non-Visual	Network	Call Data Records	✓	✓	F. Calabrese 2011
	On-device	WiFi signals measurement	✓		S. Depatla 2015
		SmartEvacTrak	✓		N. Ahmed 2015
		Social Network	✓	✓	F. Botta 2015
		Blue tooth	✓	✓	J. Weppner 2013

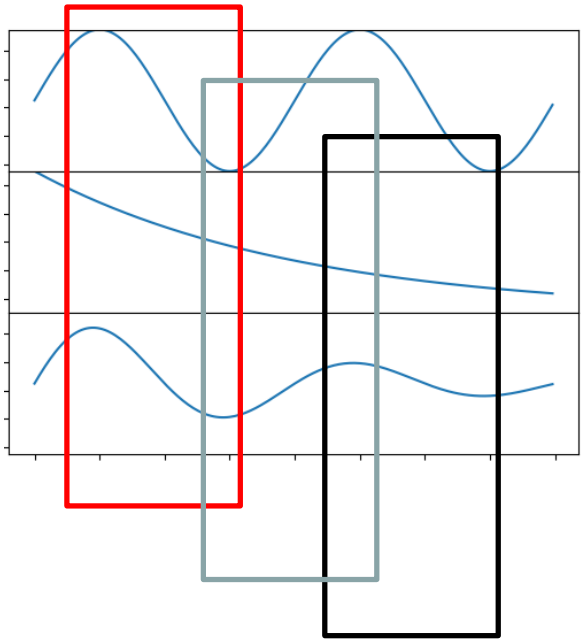
Conclusion and discussion

- Different approaches for crowd analysis based on visual and non-visual sensor have been described.
- Computer vision and smart phone based systems are presented.
- Crowd analysis applications like tracking/detection, counting, behavior analysis and anomaly detection have been discussed with reference to visual and non-visual techniques.
- Theoretical comparison is presented for tracking and density estimation.

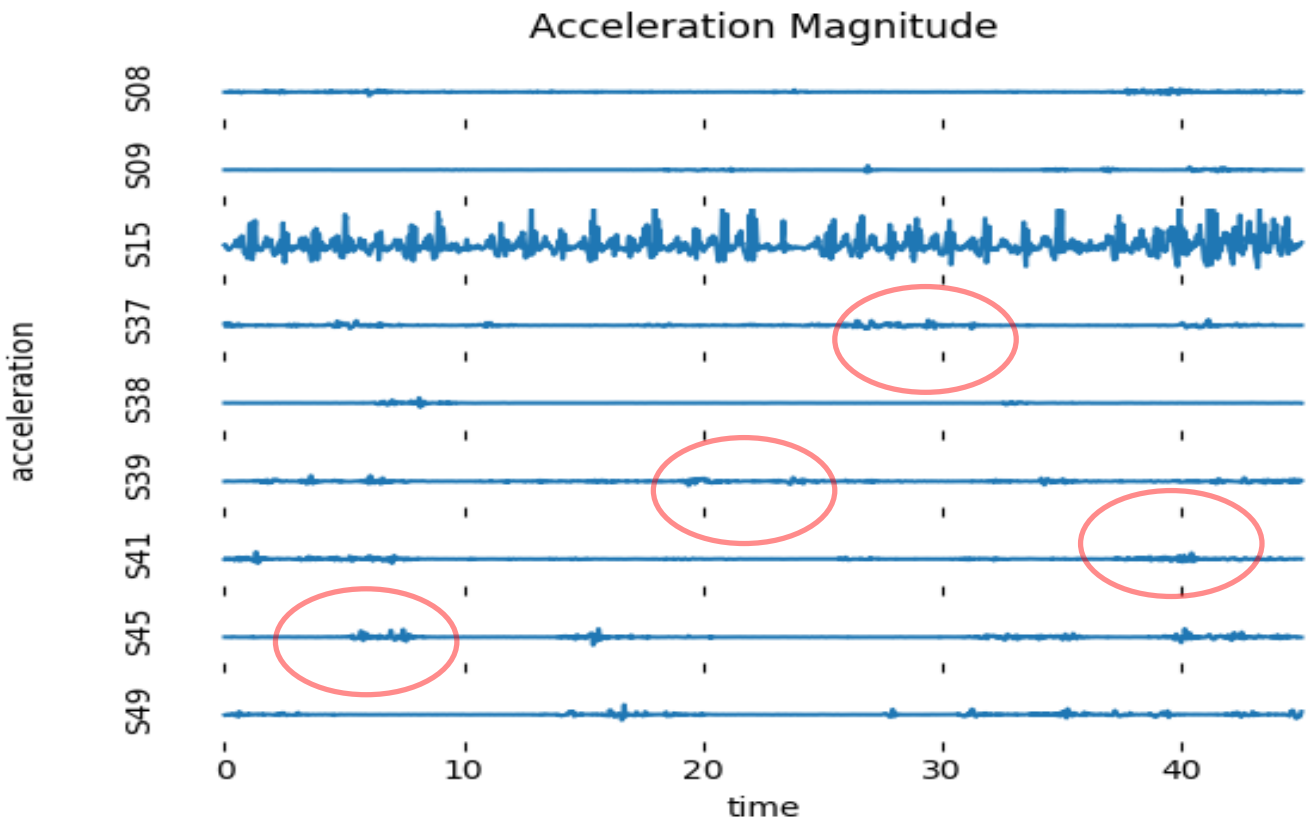
Current activities

- Experiment to investigate anomaly detection.
- Data has been collected of 9 subjects.
- Anomaly levels
  - Single subject
  - Two subjects
- An SVM based classifier will be trained and build.
- More data will be collected in the future for better evaluation.

Methods for recognition



Data visualization



Thank you! Questions?