A crowd can be defined as a large number of people gathered together in an organized or disorganized way.

**Introduction**

**Manual Monitoring**
- Time Consuming
- Error Prone

**Computer Vision-based Monitoring**
- Less Human Efforts
- Better information fusion
- Prompt, Accurate & Intelligent
- Less processing time for huge volumes of videos

**Motivation of Research**
- Existing methods are restricted to be applicable to low and medium density crowd.
- These methods lack robustness in handling densely crowded scenarios.
- Literature [5] reveals that physics-based models describe crowd behavior to a greater extent. However, the available methods partially address the issues in densely crowded scenarios. Moreover, they are more complex in functionality and are computationally expensive.

**Objectives**
- Crowd flow segmentation using physics-based model.
- Crowd characterization and analysis using Computer-vision technique.
- Development of deep machine learning models for identification of different crowd behaviors.

**Conclusion and Future Works**

The proposed Langevin-based models are simple in functionality and are able to describe human crowd movements more efficiently than other crowd movement models. The proposed models are computationally less expensive than existing state-of-the-art methods. The computer vision scheme based on Gibbs entropy is able to characterize crowd in terms of energy and randomness. The active Langevin model also characterizes crowd in terms of organization. Further, these models can be used to generate feature maps which can be used along with machine learning techniques to perform anomaly detection in dense crowded scenarios.

**Visual Surveillance for Dense Crowd Flow Analysis**

Shreetam Behera (A16EE09005)
[sb46@iitbbs.ac.in], School of Electrical Sciences, IIT Bhubaneshwar
Supervisor: Debi Prosad Dogra

**Large Gatherings in India**

- A crowd can be defined as a large number of people gathered together in an organized or disorganized way.

**Understanding Crowd Flow behavior using Langevin Equation**

**Passive Langevin Equation**

\[ \frac{d\vec{r}}{dt} = -\gamma \vec{r} + \vec{F}(\vec{r}) \]

**Active Langevin Equation**

\[ \frac{d\vec{r}}{dt} = -\gamma \vec{r} + \vec{F}(\vec{r}) + \vec{\xi}(\vec{r}) \]

where \( \vec{r} \) is the position of the particle, \( \gamma \) the velocity of the particle, mass (\( m \) = 1), \( \vec{F} \) is drift force causing the particle to drift along \( x \) direction (a positive phenomenon), and \( \vec{\xi} \) is a confinement force causing the particle to be confined along \( y \) direction (negative phenomenon).

- The random force (\( \vec{\xi}(t) \)) is generated within (0-1).

**Proposed Active Langevin Model**

\[ \frac{d\vec{x}}{dt} = \vec{F}_{\text{external}} + \vec{F}_{\text{interaction}} + \vec{\xi}(\vec{r}) \]

\[ \frac{d\vec{v}}{dt} = -\gamma \vec{v} + \vec{F}_{\text{external}} + \vec{F}_{\text{interaction}} + \vec{\xi}(\vec{r}) \]

\[ \frac{d\vec{r}}{dt} = \vec{v} \]

\[ \vec{r}(0) = \vec{r}_0 \]

**Computation of energy**

\[ E = \frac{1}{2} m \vec{v}^2 + \frac{1}{8} \gamma \vec{v}^2 \]

**Video Sequence**

- Video Sequence: (a) Original recorded Frames (31-34) of the Rath Yatra video (LEFT) and (41-44) of the Fair Video (a-h) Ground Truth Frames, (e) represents segmented output obtained using proposed method and (m-p) represents output of segmentation method [1], respectively.

**Conclusion**

**Computer Vision + Physics-based models to understand Crowd behavior**

**Crowd Characterization using Gibbs Entropy**

**Salient findings**

- Crowd dynamics in terms of randomness and energy computed with the help of Gibbs entropy and Kinetic energy.
- If significant fluctuations are observed in inter-frame energy, they indicate a fast moving crowd with higher velocity.
- If the fluctuations in inter-frame energy difference are low, then the crowd can be assumed to be moving at a uniform but lesser velocity.
- Similarly, more fluctuations in the entropy curve indicate varying randomness in the crowd. For constant entropy, the randomness can be assumed to be less in a video.

**Crowd Characterization using Active Langevin Force**

- Proposed crowd characterization model is based upon the active Langevin equation.
- Hypotheses based on the order parameter and interaction force component of the proposed model, which are enlisted below.

**H1:** Order Parameter for a structured crowd should be high and low for an unstructured crowd.

**H2:** Interaction force should be less for structured crowd and more for an unstructured crowd.

**References**


Acknowledgment: The authors would like to thank the Science and Engineering Research Board (SERB), Department of Science and Technology, Government of India for funding this research work through the grant YSS/2014/000464.