STAMPEDE DETECTION SYSTEM

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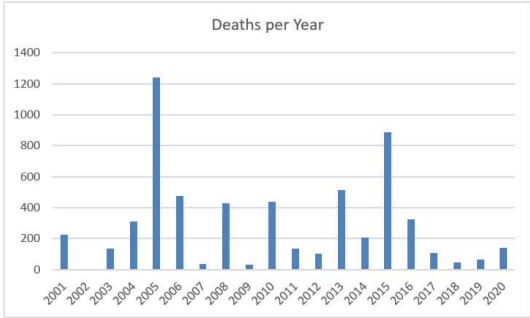
Why?

- In huge crowd gatherings, stampedes pose a huge threat to human lives. Our aim was to apply what we've learnt to solve a social problem. The advancements in hardware technology offer great potential to this model that can be used to predict a stampede and alert the concerned authorities.

- From 1980 to 2022, approximately 440 crowd surge incidents were documented, leading to over 13,700 deaths and 27,000 injuries.

- In January 2025, during the Maha Kumbh Mela festival in Prayagraj, India, a crowd crush led to at least 30 fatalities and 60 injuries.

- A few hours ago, a tragic stampede occurred at New Delhi Railway Station, resulting in at least 15 fatalities as people rushed to board a special train heading to the same Maha Kumbh Mela festival.



How?

- Stampede Detection Criteria

1. **Crowd Density**: Identifying high congestion levels in a given area.
2. **Sudden Change in Direction**: Detecting abrupt shifts in movement patterns.
3. **Motion Patterns**: Recognizing irregular movement and acceleration.

DataSet:

1. https://www.kaggle.com/datasets/danaelisanicolas/high-density-crowd-counting/data
2. https://github.com/mchengny/RWF2000-Video-Database-for-Violence-Detection

Implementation

1. Data Collection & Processing

- **Real-time Video Input**: Surveillance cameras, drones
- **Preprocessing**: Frame extraction, noise reduction, and stabilization.

  We used FiftyOne library for frame extraction and labelling.

2. AI-based Crowd Analysis

1. **Crowd Density Analysis**
   - Detect people per square meter using object detection (YOLO).
   - Predict trends using historical data and time-series analysis.

2. **Sudden Change in Direction**
   - **Optical Flow Analysis** (Lucas-Kanade, Farneback) to track movement vectors.
   - **Anomaly Detection**: Identify rapid directional shifts.
   - Correlate with **audio signals** (if available) for external disturbances.
3. **Motion Patterns & Erratic Behavior**
   - Track **acceleration spikes** using trajectory analysis.
   - Identify **unnatural clustering** with density-based clustering (DBSCAN).

3. Alert Mechanism & Visualization

- **Risk Flags**: High & Critical levels based on predefined thresholds.
- **Live Dashboard**: Real-time alerts, risk zones.
- **Automated Notifications**: Alerts sent to security teams via SMS/IoT integration.

Conditions for Risk Detection

Crowd Density Conditions

- If density > 4-5 people per square meter → **Flag as High Risk**
- If density > 6 people per square meter → **Flag as Critical Risk**
- If density increases by >20% in 30 seconds → **Trigger Alert**

Sudden Direction Change Conditions

- If >30% of individuals change direction within 2-3 seconds → **Potential Risk**
- If movement shifts from orderly to chaotic → **High Risk**
- If directional change coincides with loud noise/disturbance → **Critical Risk**

Motion Pattern & Erratic Behavior Conditions

- If many individuals accelerate beyond 1.5× normal speed → **Potential Risk**
- If clustering occurs abnormally → **High Risk**
- If multiple irregular movements (stopping, pushing, turning) happen simultaneously → **Critical Risk**

Conclusion and Future Work

- Implement the proposed framework.
- Add prediction algorithms for early risk detection.