PROJECT ABSTRACT

Drowning Detection in Pools using CNN

A motion-based vision monitor that scores pool camera feeds for drowning-like distress patterns and raises alert candidates for human review — an educational prototype, never a safety device.

01. Title

Drowning Detection in Pools using CNN

02. Introduction / Background

Drowning is silent and fast: a struggling swimmer cannot call for help, and a lone lifeguard cannot watch every corner of a busy pool at once. Automated pool monitoring is an active research area, but the honest framing for a student project is an alert aid, not a safety device — a vision system that flags suspicious motion patterns for a human to check, with documented failure modes and no life-safety claims. This project builds that aid: OpenCV frame differencing produces motion maps from pool camera feeds, pose cues from MediaPipe track swimmer movement, and a lightweight classifier scores motion sequences over a time window for distress-like patterns such as prolonged struggling or bobbing without net displacement. The alert logic requires sustained patterns so passing splashes and normal play do not become alerts, and every alert candidate is logged with a timestamp and snapshot for human review. Evaluation runs on buyer-staged footage with volunteers acting out scenarios, because real drowning footage is neither available nor ethical to collect.

03. Problem Statement

Pool staff cannot continuously watch every swimmer, and automated monitoring that claims safety-grade reliability would be dishonest in a student project. The need is a vision-based alert aid that detects motion in pool camera feeds, tracks swimmer movement with pose cues, scores motion sequences for distress-like patterns, alerts only on sustained patterns for human review, and evaluates its alert rule on ethically staged footage — while being honest that it is a prototype, never a safety device, and never a substitute for lifeguards or supervision.

04. Objectives

The objectives are to build a frame-differencing motion pipeline for pool camera feeds; to track swimmers with MediaPipe pose cues; to score motion sequences for distress-like patterns with a lightweight classifier; to implement a time-window alert rule over

sustained patterns; to log alert candidates with timestamps and snapshots; and to evaluate the alert rule's precision and recall on buyer-staged footage via the included notebook.

- Build a frame-differencing motion pipeline for pool camera feeds.
- Track swimmers with MediaPipe pose cues.
- Score motion sequences for distress-like patterns over a time window.
- Implement a time-window alert rule for sustained patterns.
- Log alert candidates with timestamps and snapshots for human review.
- Evaluate alert-rule precision and recall on buyer-staged footage.

05. Proposed System / Working

Pool camera frames are sampled and background subtraction with frame differencing produces per-frame motion maps; motion regions are filtered by area and persistence while static water-ripple noise is suppressed with temporal smoothing. MediaPipe pose landmarks track swimmers, measuring vertical bobbing and displacement over the time window. A lightweight classifier scores each motion sequence for distress-like patterns — sustained struggling motion without net displacement. Patterns persisting across the time window become confirmed alert candidates logged with timestamp and snapshot; isolated blips are discarded. The demo app serves the motion view and the alert log. The notebook runs the buyer-staged evaluation: labeled scenarios are replayed through the pipeline and the alert rule's precision and recall are computed.

- OpenCV frame differencing for per-frame motion maps.
- Area and persistence filtering with ripple-noise suppression.
- MediaPipe pose cues for bobbing and displacement measurement.
- Motion-sequence classifier scoring distress-like patterns.
- Time-window alert rule over sustained patterns.
- Timestamped alert log with frame snapshots.
- Notebook evaluation: alert-rule precision and recall on staged footage.

06. Technologies / Components Used

The system uses Python 3.10 with OpenCV for frame differencing and motion maps, PyTorch for the motion-sequence classifier, and MediaPipe for body landmarks and motion cues. NumPy and pandas manage motion features and alert logs; Matplotlib plots motion timelines and evaluation results; a Jupyter notebook runs the staged-footage evaluation procedure; and a Flask app serves the demo with a camera-feed upload interface.

- Python 3.10, OpenCV (frame differencing, motion maps).
- PyTorch (motion-sequence classifier training).
- MediaPipe pose (body landmarks and motion cues).

- NumPy, pandas (motion features and alert logs).
- Jupyter notebook (staged-footage evaluation procedure).
- Matplotlib (motion timelines and evaluation plots).
- Flask demo app with camera-feed upload interface.

07. Key Features

Key features include frame-differencing motion maps, MediaPipe pose cues for swimmer tracking, a motion-sequence classifier for distress-like patterns, distress heuristics covering prolonged splashing and bobbing without displacement, a time-window alert rule, a timestamped alert log with snapshots, and a buyer-run staged-footage evaluation procedure computing the alert rule's precision and recall — always framed as an educational prototype, never a safety device.

- Frame-differencing motion maps from pool camera feeds.
- MediaPipe pose cues tracking swimmer movement.
- Motion-sequence classifier for distress-like patterns.
- Distress heuristics: prolonged splashing, bobbing without displacement.
- Time-window alert rule suppressing single-blip alerts.
- Timestamped alert log with annotated snapshots.
- Staged-footage evaluation: alert-rule precision and recall.
- Demo app with motion view and alert log.

08. Applications / Use Cases

Pool distress-pattern monitoring applies to lifeguard-assist alerting prototypes, swimming-lesson monitoring aids, water-park surveillance research, and aquatics-safety education. It also demonstrates motion analysis, pose tracking, and time-window alert design as viva-ready computer-vision concepts — always framed as an alert aid, never as a safety device.

- Lifeguard-assist alerting prototypes.
- Swimming-lesson monitoring aids.
- Water-park surveillance research.
- Aquatics-safety education material.
- Teaching motion analysis and pose tracking.

09. Results & Scope

The expected outcome is a working distress-pattern monitor whose alert quality is measured, not asserted: the included notebook replays buyer-staged scenarios (volunteers acting out normal swimming, play and distress patterns) and computes the alert rule's precision and recall on that labeled set. Scope covers visible-light pool camera feeds from overhead or side views; documented limits include the critical false-

negative mode — a still, submerged victim produces little motion and can be missed — plus busy pools, glare, reflections and swimmers outside the camera's view. This is an educational prototype, NOT a safety device: it must never substitute lifeguards, adult supervision or certified pool-safety equipment, and it must never be deployed where people depend on it. Future scope includes multi-camera coverage, depth-sensing inputs, and surface-texture analysis for submerged-victim detection research.

- Measured outcome: alert-rule precision and recall computed by the notebook on buyer-staged footage.
- Staged scenarios with volunteers acting out labeled behaviors.
- Scope: visible-light pool camera feeds from overhead or side views.
- Documented limits: still-victim false negatives, busy pools, glare, out-of-view swimmers.
- Honest framing: educational prototype, never a safety device or supervision substitute.
- Future scope: multi-camera coverage, depth sensing, submerged-victim research.

10. Conclusion

Frame differencing, pose cues and a time-window alert rule make drowning-like pattern monitoring a tractable student-buildable system, and this project delivers it as a complete auditable experiment: motion pipeline, pose tracking, pattern scoring, alert logic, and a notebook that measures the alert rule's precision and recall on staged footage. Built to order, it ships with source code, the evaluation notebook, report, presentation, and viva preparation material.

11. References

The project cites the MediaPipe pose framework, the Farnebäck motion-estimation method, and a multi-object tracking reference.

- V. Lugaresi et al., 'MediaPipe: A Framework for Building Perception Pipelines,' arXiv:1906.08172, 2019.
- G. Farnebäck, 'Two-Frame Motion Estimation Based on Polynomial Expansion,' Proc. SCIA, 2003.
- A. Bewley, Z. Ge, L. Ott, F. Ramos, and B. Upcroft, 'Simple Online and Realtime Tracking,' Proc. ICIP, 2016.