A Deep Learning-Based Drowning Detection Method for Dynamic Swimming Pool Environments Using Spatiotemporal Neighborhood Analysis

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Drowning detection in dynamic swimming environments is a challenging problem in computer vision, for which no satisfiable solutions have been found. Currently known methods primarily rely on background subtraction-based techniques; however, random motion caused by water rippling, splashing, and moving reflections frequently result in interference and inaccuracies. In this work, an alternative solution for real-time drowning detection was developed using deep learning technology. The method uses a Convolutional Neural Network (CNN) head detector to generate confidence maps of head locations in a pool, and Non-Maximum-Suppression to extract the heads' pixel coordinates. A Kalman Filter is then applied to track the heads' continuity within the 3D spatio-temporal domain. Through analyzing curve discontinuities and swimmer locality, the algorithm can determine whether a swimmer is exhibiting drowning behavior. The criteria used to make these determinations were derived from the American Red Cross' published characteristics for drowning. As soon as drowning behavior is identified in a region, a warning is issued. This model was tested on videos of drowning and regular swimming under a variety of environmental and lighting conditions. For each tested case within the accepted resolution range, the system successfully identified the drowning event with low latency and produced the appropriate warning. Unlike existing detection algorithms, which rely on background subtraction and require custom filtering/convoluted logic rules, the proposed ANN system can be utilized in a variety of environments without modifications or professional installation. This new technique offers a promising step towards the real-world implementation of drowning surveillance systems in pools.

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