Tracking System for Boxers

CSCI510
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Problem Setting
Goal

- Create a system to track the movement of boxers during a fight
- Experiment with and compare methods of motion tracking on multiple objects
Motivation

- Computer vision techniques can provide sports statistics that were previously unavailable
- Examples include:
  - Goal detection system used during the World Cup
  - ESPN’s ‘advanced statistics’
Motivation

● For boxers:
  ○ Compute distance travelled during a fight
  ○ Generate paths and heat maps to identify movement tendencies
Assumptions

- Boxing ring is a 20 ft x 20 ft square, with rounded edges due to camera distortion.
- A boxing match includes 1 referee and 2 boxers.
- Data used is from practice bouts and doesn’t follow typical boxing time rules.
Typical Camera View
Related Work
Previous Research

- Project from CSCI512 experimented with Gaussians for segmentation, CAMShift for tracking
- State of the art in motion tracking algorithms:
  - Kalman Filters
  - Mean Shift
My Work
Overview

- Each frame was subtracted from a background template
- Dilation/erosion was then used to clean up the resulting foreground image
- 3 different methods of tracking connected components were used
  - Distance Method
  - Kalman Filter
  - Histogram Similarity Method (~CAMShift)
Background and Segmented Boxers
Connected Components - Distance Method

- Based on distance
- Algorithm iterates through the largest regions found within the boxing ring.
- For each person, assumption is that the nearest ‘large’ region is the new location for that person.
- If no region was within a threshold, just use the previous location.
Connected Components - Kalman Filter

- Kalman filter is an algorithm that uses a series of noisy measurements to make a prediction about future state.
- Very commonly used in motion tracking for traffic, pedestrians, and some sports.
Connected Components - Kalman Filter

- Used to supplement the original connected components tracking algorithm.
- If no region was found nearby the previous location for a person, use the Kalman filter to predict the location.
Connected Components - Histogram Method

- Similar to distance method - identifies large regions within the boxing ring.
- For each person, finds the region with the most similar histogram to its previous location’s histogram.
Connected Components - Histogram Method

- Similar idea to CAMShift, which builds a probability function across the image based on histogram similarity
- My implementation isn’t probability based but simply finds the most similar object based on its histogram
Results
Distance Implementation: Paths
Distance Implementation: Heatmaps
Kalman Filter: Paths
Histogram Similarity: Paths
Histogram Implementation: Heatmaps
Performance

- Annotated boxer positions by hand every 10 frames
- Tracked two main stats to determine performance:
  - Total Error: Distance in pixels from detected position to actual position
  - Total Error with a Threshold: Same as the first, but only if the distance was above a threshold
Performance

- Histogram based method performed better in terms of total error
  - Worse when error was only counted if above a certain threshold
  - Meaning the distance based method isn’t as accurate but makes fewer big mistakes
Performance

- A combination of methods would probably be best suited - histogram similarity as the main component but falling back to the distance method as a sanity check.
The Next Step
Limitations / Improvements

● The background segmentation method is definitely a limitation.

● More effective methods would provide a clearer set of connected components to analyze
  o Mixture of Gaussians
  o Robust PCA
Limitations

- Kalman filters not best suited for objects with erratic motion
- ‘Best’ solution from my methods would be a combination of histogram similarity and distance
Questions?