Automated Pitch Segmentation and Grid Overlay Using Computer Vision

Objective

The objective of this component is to automatically detect the playable area of a football pitch and divide it into standardized zones, enabling quantitative assessment of player positioning and pressing behaviors. Instead of analyzing the pitch as a continuous surface, discretization into predefined zones provides a consistent spatial framework for computing **pressure metrics**.

This approach was implemented and tested on recordings obtained from a **VEO tactical camera system**, which provides panoramic coverage of the entire pitch from a fixed elevated position.

1. Pitch Segmentation Pipeline

The pipeline for isolating the pitch consists of several steps:

(a) Color Space Conversion

Each frame was converted from RGB to HSV color space. HSV is preferred because it separates chromatic content (hue) from brightness, which improves robustness under variable lighting conditions.

(b) Green Range Thresholding

A fixed green color range was defined in HSV space:

Lower bound=[45,70,80],Upper bound=[70,255,255]

This range was tuned to capture both light and dark patches of grass while excluding crowd, advertising boards, and other non-pitch objects.

(c) Morphological Refinement

To remove noise, **morphological opening and closing** operations were applied using a 9×9 kernel:

- Opening eliminated small isolated green pixels.
- Closing filled small gaps within the detected pitch.

(d) Spatial Region Masking

To exclude areas outside the playable surface, a spatial region mask was applied. This restricted candidate pixels to a central rectangular band, reducing false positives from the crowd, sky, or stadium.

(e) Contour Extraction and Filtering

Contours were extracted from the refined mask and evaluated against geometric rules:

- Minimum area: > 8% of frame size
- Aspect ratio: $1.8<W/H<51.8$
- Solidity: > 0.7
- Centroid vertical range: between 30% and 90% of image height

2. Grid Overlay Construction

After pitch segmentation, the grid overlay was generated as follows:

(a) Field Corner Approximation
The four pitch corners were approximated in the image plane:

- Top-left: [0.10W,0.10H]
- Top-right: [0.90W,0.10H]
- Bottom-right: [0.99W,0.99H]
- Bottom-left: [0.01W,0.99H]

(where W = width, H = height of the frame).

(b) Perspective Normalization
A perspective transformation matrix MM was computed to map these four corners to a unit square ([0,0], [1,0], [1,1], [0,1]).

(c) Grid Generation
An **8 × 6 grid** was generated in normalized space. This size was selected to provide sufficient granularity for tactical analysis without excessive computational overhead.

(d) Re-Projection and Overlay
The normalized grid lines were re-projected into the original frame using the inverse of MM. The overlay was restricted to the detected pitch mask, ensuring that lines did not extend into non-pitch regions.

3. Visualization Outputs

The following outputs were generated to evaluate the method:

1. **Original Frame** – unprocessed video input.
2. **Green Mask (Final VEO Method)** – binary segmentation highlighting the pitch.
3. **Green Pitch Overlay** – pitch region retained and background suppressed.
4. **Grid Overlay on Pitch** – 8 × 6 grid applied on the pitch surface.

Figure 1: green mask and pitch overlay results

Figure 2: grid overlay on pitch

4. Testing and Evaluation

The method was tested on multiple VEO tactical camera recordings. Observations include:

- **Robust segmentation**: The pitch was consistently detected under different lighting and crowd conditions.
- **Accurate perspective handling**: The grid aligned well with the field even under angled viewpoints.
- **Practical discretization**: The 8 × 6 grid provided a good balance between tactical resolution and computational feasibility.

This validated pipeline provides the foundation for computing **pressure metrics**, as each grid cell can serve as a discrete unit for analyzing pressing density, player occupation, and ball recovery opportunities.