

Image Processing and Computer Vision

Motion Analysis and Tracking

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Motion in Image Sequences

Definition

Motion analysis studies how objects move across a sequence of images or video frames. A video can be considered as a sequence of images captured over time.

- A video consists of multiple frames captured sequentially.
- Motion is observed when objects change position between frames.
- By comparing consecutive frames, it is possible to estimate object movement.

Example

Consider a ball moving in a video:

Frame 1 $\rightarrow$ Frame 2 $\rightarrow$ Frame 3

If the ball appears at different positions in each frame, the displacement represents motion.

- Position changes indicate object motion.
- Temporal analysis reveals movement patterns.
- Foundation for optical flow and tracking techniques.

Why Motion Analysis is Important

Important

Understanding motion allows computer vision systems to detect, track, and analyze moving objects in video sequences.

- Autonomous vehicles
- Robot navigation
- Surveillance and security systems
- Sports analytics
- Human activity recognition
- Video stabilization

Optical Flow Fundamentals

Definition

Optical flow describes the apparent motion of pixels between two consecutive image frames.

- Each pixel may have a motion vector.
- A motion vector represents the direction and magnitude of motion.
- Optical flow estimates how image intensities move between frames.

Important

Optical flow assumes that the brightness of a pixel remains approximately constant between consecutive frames.

Sparse Optical Flow: Lucas–Kanade Method

Definition

The Lucas–Kanade method estimates motion only for selected feature points rather than for every pixel in the image.

- Tracks motion of distinctive image features.
- Efficient and suitable for real-time applications.
- Often used for feature tracking in video sequences.

Important

Instead of tracking all pixels, only key points such as corners are tracked across frames.

For a detailed tutorial on the Lucas–Kanade method, see: [Lucas–Kanade Method Tutorial](#)

Dense Optical Flow: Farneback Method

Definition

Dense optical flow estimates motion for every pixel in the image, producing a complete motion field.

- Computes motion vectors for all pixels.
- Provides a detailed representation of motion in the scene.
- Useful for analyzing complex motion patterns.

Note

Dense optical flow provides more detailed motion information but requires more computational resources.

Background Subtraction

Definition

Background subtraction is a technique used to detect moving objects by separating foreground objects from a static background.

- A background model is first created.
- Each new frame is compared with the background model.
- Differences are detected as moving objects.

Example

In a surveillance camera, the background is typically static while people or vehicles appear as moving foreground objects.

Feature Tracking

Definition

Feature tracking refers to following specific image features across multiple frames of a video sequence.

- Features such as corners or keypoints are detected.
- Their movement is tracked between frames.
- Motion information can be estimated from these tracked features.

Important

Feature tracking is commonly used in robotics, visual SLAM, augmented reality, and video stabilization.

Concept Summary

- Motion analysis studies how objects move across image sequences.
- Optical flow estimates pixel motion between frames.
- Lucas–Kanade computes sparse optical flow using feature points.
- Farneback computes dense optical flow for all pixels.
- Background subtraction detects moving objects in video.
- Feature tracking follows keypoints across frames.