Module 2: Ball and Object Tracking Module Interface

Group Name: Huzz DRS
Members: 22L-6563, 22L-6804, 22L-6808, 22L-6940, 22L-6967

Module Responsibility: The Ball and Object Tracking Module is a critical component of the DRS (Decision Review System) that detects and tracks key objects in cricket matches, including the ball, stumps, batsman, and bat. This module receives video frames from the Mobile UI (Camera Module) and processes them to extract positional data, which is then passed to the Bat's Edge Detection Module.

Input

Field	Type	Description
frame_id	Integer	Unique sequential ID for the frame
timestamp	String	ISO 8601 formatted time of frame capture
data	Integer	Base64-encoded JPEG/PNG image data
Resolution	2 Integers	Width and height of the resolution
cameraPosition	3 Floats	X,y and z position of the camera after calibrating
Pitch, yaw, roll	3 floats	Rotations of the camera in the three axis
Audio_Id	String	Id of the audio data of the frame
data	String	Base64 encoded audio data of the frame

Output (Per Frame)

Each video frame is captured and transmitted as an individual message with metadata. This ensures real-time streaming and processing across modules.

Field	Type	Description
frame_id	Integer	Unique sequential ID for the frame
timestamp	String	ISO 8601 formatted time of frame capture
data	String	Base64-encoded JPEG/PNG image data
Audio_Id	String	iD referencing the associated audio sample
data (audio)	String	Base64-encoded audio data for the frame
ball_data	Object	Ball position, velocity, spin, and historical positions
bat_data	Object	Bat handle, tip, edge positions, orientation, velocity, and confidence

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Output Example (JSON)


```
{
  "tracking_data": {
    "frame_id": 1542,
    "timestamp": "2025-04-02T11:02:47.123Z",
    "processing_timestamp": "2025-04-02T11:02:47.145Z",
    "delivery_id": "2025040201-D127",
    "match_id": "IPL2025-M042",
    "confidence_score": 0.94
  },
  "ball_trajectory": {
    "current_position": {
      "x": 12.45,
      "y": 1.2,
      "z": 0.85
    },
    "velocity": {
      "x": -28.5,
      "y": 0.2,
      "z": -1.8
```

```
    },
    "acceleration": {
      "x": 0.1,
      "y": -9.8,
      "z": 0.05
    },
    "spin": {
      "axis": {
        "x": 0.1,
        "y": 0.8,
        "z": 0.2
      },
      "rate": 25.5
    },
    "detection_confidence": 0.96,
    "historical_positions": [
      {
        "frame_id": 1540,
        "position": {
          "x": 13.2,
          "y": 1.25,
          "z": 0.9
        },
        "timestamp": "2025-04-02T11:02:47.056Z"
      },
      {
        "frame_id": 1541,
        "position": {
          "x": 12.8,
          "y": 1.22,
          "z": 0.87
        },
        "timestamp": "2025-04-02T11:02:47.089Z"
      }
    ]
  },
  "batsman_data": {
    "position": {
      "x": 10.2,
      "y": 0.0,
      "z": 0.0
    },
    "leg_position": {
      "left_foot": {
```

```
        "x": 10.1,
        "y": 0.0,
        "z": -0.2
      },
      "right_foot": {
        "x": 10.3,
        "y": 0.0,
        "z": 0.2
      },
      "left_knee": {
        "x": 10.1,
        "y": 0.5,
        "z": -0.15
      },
      "right_knee": {
        "x": 10.3,
        "y": 0.5,
        "z": 0.15
      }
    },
    "stance": "right-handed",
    "body_orientation": {
      "pitch": 5.0,
      "yaw": 85.0,
      "roll": 2.0
    },
    "detection_confidence": 0.92
  },
  "bat_data": {
    "position": {
      "handle": {
        "x": 10.4,
        "y": 1.1,
        "z": 0.1
      },
      "middle": {
        "x": 10.6,
        "y": 0.7,
        "z": 0.2
      },
      "edge": {
        "x": 10.65,
        "y": 0.7,
        "z": 0.22
```

```
      },
      "tip": {
        "x": 10.8,
        "y": 0.3,
        "z": 0.3
      }
    },
    "orientation": {
      "pitch": 45.0,
      "yaw": 10.0,
      "roll": 5.0
    },
    "velocity": {
      "x": 5.2,
      "y": -2.1,
      "z": 0.5
    },
    "detection_confidence": 0.91
  },
  "stumps_data": {
    "position": {
      "base_center": {
        "x": 9.0,
        "y": 0.0,
        "z": 0.0
      }
    },
    "orientation": {
      "pitch": 0.0,
      "yaw": 0.0,
      "roll": 0.0
    },
    "individual_stumps": [
      {
        "id": "leg",
        "top_position": {
          "x": 9.0,
          "y": 0.71,
          "z": -0.11
        }
      },
      {
        "id": "middle",
        "top_position": {
```

```
          "x": 9.0,
          "y": 0.71,
          "z": 0.0
        }
      },
      {
        "id": "off",
        "top_position": {
          "x": 9.0,
          "y": 0.71,
          "z": 0.11
        }
      }
    ],
    "bails": [
      {
        "id": "leg_bail",
        "position": {
          "x": 9.0,
          "y": 0.71,
          "z": -0.055
        },
        "is_dislodged": false
      },
      {
        "id": "off_bail",
        "position": {
          "x": 9.0,
          "y": 0.71,
          "z": 0.055
        },
        "is_dislodged": false
      }
    ],
    "detection_confidence": 0.98
  },
  "pitch_data": {
    "pitch_map": {
      "length": 20.12,
      "width": 3.05,
      "center": {
        "x": 0.0,
        "y": 0.0,
        "z": 0.0
```

```
    }
   },
   "bounce_point": {
    "position": {
     "x": 11.2,
     "y": 0.0,
     "z": 0.1
    },
    "frame_id": 1538,
    "timestamp": "2025-04-02T11:02:46.989Z",
    "detection_confidence": 0.89
   }
  }
}
```


Note: The `data` field holds the actual image content encoded in Base64. This can be decoded by downstream modules to reconstruct the image.

Output Stream Considerations

- The module should output tracking data for each processed frame or at a minimum rate of 30 updates per second.
- All coordinates use a consistent coordinate system with the origin (0,0,0) at the center of the pitch at ground level.
- The x-axis runs along the length of the pitch from bowler to batsman.
- The y-axis represents height from the ground.
- The z-axis runs perpendicular to the pitch length, with positive values toward the off side for a right-handed batsman.
- Confidence scores should be provided for each detected object to indicate reliability.
- Historical positions should be included to enable trajectory analysis and prediction.

Performance Requirements

The Ball and Object Tracking Module should meet the following performance criteria:

- Processing Speed: Process frames at a minimum of 30 fps on recommended hardware.
- Latency: Maximum end-to-end latency of 100ms from frame capture to output generation
- Accuracy: Ball position accuracy: ±2cm in all dimensions
- Object detection reliability: >95% under normal conditions False positive rate: <1%

- Robustness: Maintain tracking through partial occlusions and varying lighting conditions

Data flow diagram: