# Sioux Bulls Team Description Paper 2025

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**Abstract.** This paper presents the design and development of Sioux Bull's autonomous soccer robot for the RoboCup Middle Size League (MSL). The system integrates two key innovations: the swerve drive and ZED stereoscopic cameras. These innovations enable omnidirectional mobility and precise environmental interaction, demonstrating advancements in robotic autonomy and dynamic control.

**Keywords:** RoboCup Middle Size League, autonomous soccer robots

## 1 Swerve Drive System for Dynamic Motion

Our robot employs a motion base that includes four independently steered and driven wheels (Fig. 1). Each swerve drive module integrates a brushless DC motor for steering and propulsion, respectively. Each motor is equipped with encoder for feedback control.

### 1.1 Motion Control and Set Point Generation

The robot achieves enhanced maneuverability through the implementation of a swerve drive system, which enables omnidirectional mobility via independent wheel vectoring. However, the kinematic redundancy introduced by this design complicates motion coordination, necessitating precise trajectory planning and dynamic control. To address these challenges, we employ the following approaches:

- **Synchronized Trajectory Planning**: Paths are generated for the robot as the result of path planning. This robot-level path is decomposed to individual wheels to ensure synchronized motion profiles.
- **Decentralized PID Control**: Each wheel module runs a PID loop for simultaneous velocity and angle tracking. EtherCAT bus synchronization ensures low latency between modules.

## 2 ZED Cameras for Robot Perception

We integrate ZED stereoscopic cameras into our robotic system. The camera provides critical advancements in environmental perception, enabling robust object detection and precise localization. As an RGB-D sensor, the ZED camera combines high-resolution 1080p RGB imagery with dense depth maps derived from stereo vision, offering a spatial resolution of up to 4416×1242 pixels and a depth range of 0.3–25 meters. This section details our implementation of the ZED camera's capabilities within the robot's perception pipeline.

The ZED SDK facilitates real-time object detection by fusing RGB data with depth information through the following workflow:

- **RGB Stream Processing**: A YOLOv8 model [1], fine-tuned on RoboCup-specific datasets, identifies objects (e.g., balls, goals, obstacles) in the RGB feed.
- **Depth Masking**: Depth maps from the ZED camera filter false positives by constraining detections to physically plausible distances (e.g., rejecting "ball" detections beyond 5 meters).
- **Edge Deployment**: The model runs on an NVIDIA Jetson Orin NX, achieving fast inference with TensorRT optimization.

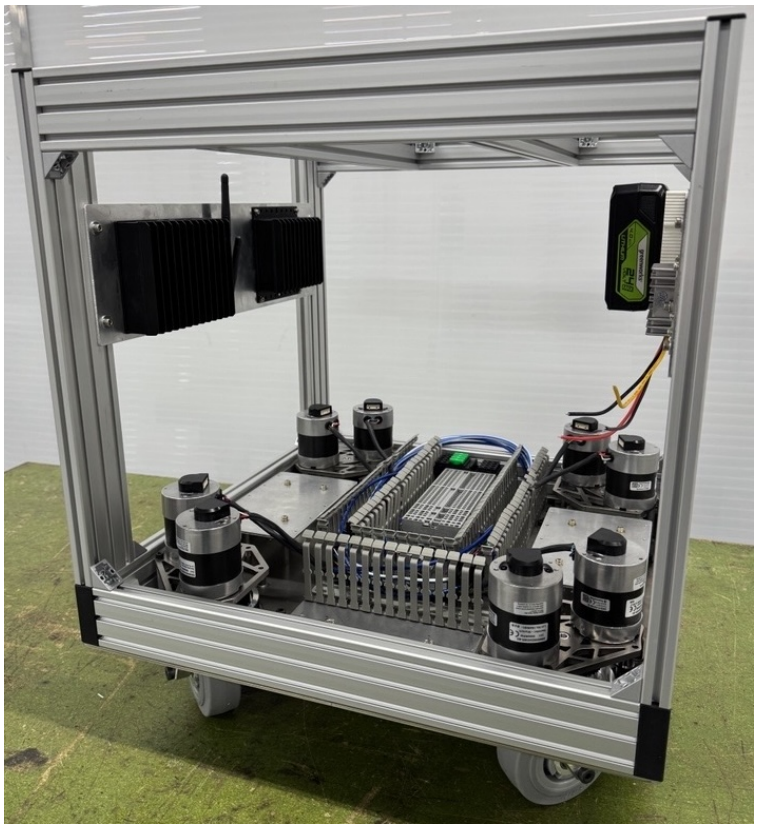

**Fig. 1.** Swerve drive modules with steering and propulsion motors.

## 3 Conclusion

The paper details two core components of a robotic system: a swerve drive for dynamic motion and ZED cameras for perception. The integration of these systems advances robotic autonomy, enabling high-precision motion and perception in complex scenarios.

## References

1. Jocher, G., "YOLOv8: State-of-the-Art Object Detection," Ultralytics, 2023.