

MoonSafe

Collision Avoidance System for Lunar Construction Sites

FORUM8

14th CPWC

STRL Team

Overview

Construction sites on Earth are dangerous, but we have paved roads, land markings and clear daylight visibility. Shifting this construction site to the Moon, situation will be different: no paved roads, land markings or traffic lights, sunlight that transitions to shadow abruptly, and darkness that lasts for nearly two weeks with dust floating on the regolith surface. This environmental characteristics directly restricts driver's visibility, so an object directly ahead may not be recognized until it is too late to react. MoonSafe was designed to address the challenge.

System

UC-win/Road simulates the vehicle, road, designed lunar terrain and outputs the data in real time. When a collision course is confirmed by TTC calculation, automatic brake command is sent directly to the user vehicle, and collision warning alarm is displayed on the UI through UDP 4001.

UC-win/Road
Simulation engine: vehicle physics, roads, objects, geometric condition

SDK: objects within 100 m

MoonSafe Auto Brake
TTC-based control command, Python API

UDP 4000 / UDP 4001

MoonSafe radar
Vehicle location visualization, TTC-based risk detection, alert system UI



Python-based flow: Data collection → Collision calculation (TTC) → Brake command

For moving objects such as another vehicle, MoonSafe immediately adds extra margin to the TTC calculation: 2.0 plus 0.6 meters per velocity of the object.

Development Details

Experimental Network Setup
UC-win/Road

Python Development Environment Setup
Use of python libraries

GPS-based object detection program
Python-based User Interface radar

Calculation of distance
between vehicle and surrounding objects

Automatic braking based on TTC
PythonAPIPlugin

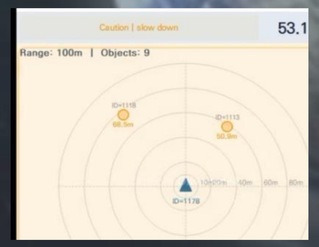
TTC based alert state system
Alert Level Green / Yellow / Red / Stop

Development of GPS-based autonomous driving capabilities for the lunar surface: Sensing / Perception / Localization, Prediction / Path Planning / Control / Actuation.

TTC Alert Levels



Green: TTC above 6 s. Normal operation



Yellow: 6 to 3 s. Caution message, voice guidance

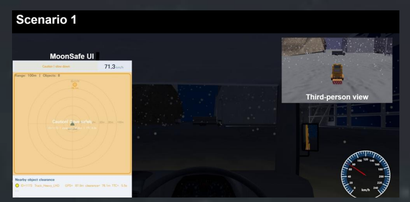


Red: 3 to 1.5 s. Warning message and alerts

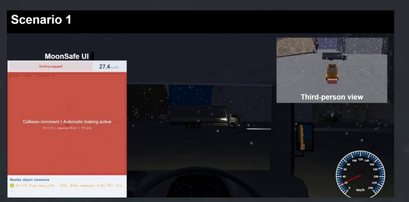


Collision Alert: below 1.5 s. Brake command engaged

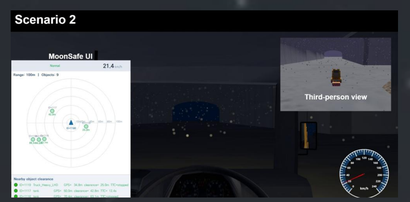
Result



Scenario 1 (a):
risk level shown via UI



Scenario 1 (b):
automatic braking to 0 km/h



Scenario 2:
driver widens the turning radius

MoonSafe radar continuously detects every object within 100-meter range, and is useful in situation when the object is visually disable. As a result, the user can safely bypass the object.

Future



MoonSafe Road Map

Stage 1: Driver safety net, intervening only in critical situations

Stage 2: Continuous driver assistance, with expanded intervention

Stage 3: Integration as the core decision module of end-to-end (E2E) autonomous driving

Collision prediction and braking	prediction-time margin proportional to communication latency; braking distance, inertial dynamics and friction models remodeled for lunar gravity and regolith; LIDAR-based emergency backup for GPS transmitter failure.
Evaluation framework	crater, slope, inter-rover collision and sensor malfunction scenarios; TTC probability distribution, braking error and detour rates.
Expected outcomes	reduced collision rate, a generalized framework for future lunar surface projects, and unmanned validation before manned application.