Connected Wise

WHITE PAPER

PROJECT PITCH

VISUAL MAPPING IDENTIFIERS FOR AUTONOMOUS VEHICLE NAVIGATION

IN RESPONSE TO
THE U.S. DEPARTMENT OF DEFENSE SOLICITATION HQ0845-22-S-N001
Commercial Acceleration Opportunity (CAO) for National Security Innovation Capital (NSIC)

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Executive Summary

Connected Wise is interested in collaborating with defense agencies to address the positioning, navigation, and timing (PNT) challenges of military robotics and autonomous systems (RAS) particularly in GPS denied environments. Our technology uses secure visual mapping identifiers placed at certain intervals on the transport routes.

Motivation

- Most robotic and autonomous systems rely heavily on GPS/GNNS for localization, mapping, and navigation.
- Military operations are often executed in GPS-denied environments; such as urban areas, forests, and canyons.
- RAS offer the potential to change the nature of warfare in that can potentially reduce the risks to soldiers and marines.
- Since PNT plays a significant role in the deployment of RAS, addressing PNT challenges is critical to defense agencies.

Problem

Localization and mapping can be difficult for robotics and autonomous systems due to the visual similarity of terrain.

Alternative solutions to PNT challenges such as LIDAR , RADAR and other sensor fusion solutions are expensive and their accuracy depends environmental factors. Signal-based solutions on the other hand are vulnerable to cyber attacks.

Solution

Connected Wise has developed a machine vision based communication technology that will support the autonomous navigation of military robotics & autonomous systems.

When the mapping identifier is recognized by the vehicle's camera, the system will calculate the relative position of the vehicle in reference to surveyed mapping data.

Technological Advantage

Cyber-security

The visual identifiers are essentially unique images generated from an extremely secure visual hashing algorithm. This prevents a third-party from altering the information.

Robust Operation

It enables the machine vision system to utilize robust image recognition. Hence, the system can operate under challenging circumstances created by extreme ambient conditions.

Low-cost System

The system will not require additonal infrastracture or power to operate. Compared to wireless communication solutions, it is 95% more cost effective.

Invisible Application

Using UV Reflective Markers :

- Invisible application prevents a third-party from interfering the mapping identifier. They can be applied onto existing signs or structures using transparent UV blocking thin-film.
- The mappping identifiers can be also applied on any flat topography such as pavement and asphalt surfaces using UV reflective invisible markers.
- The terrain mapping information can be updated without the need to replace the identifiers. If damaged, emergency navigation data can be engaged for a safer route.

UV Image

Visible Image

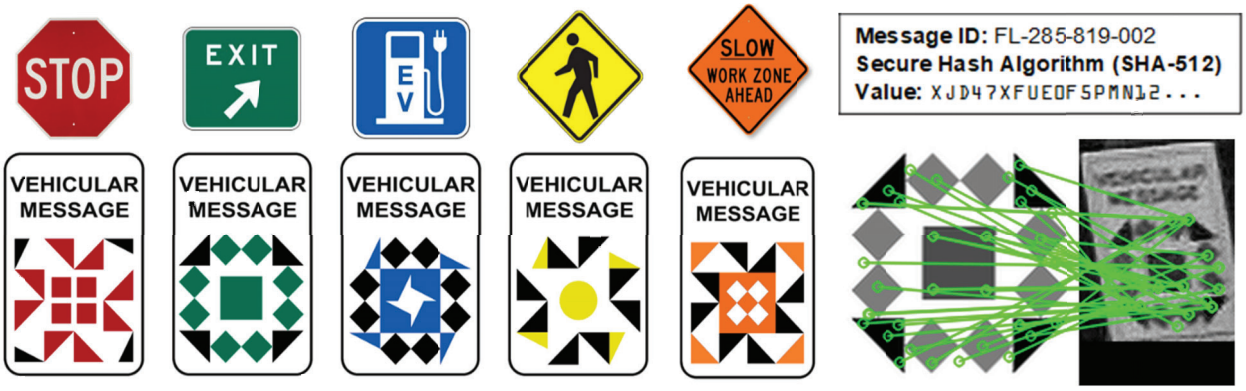
Methodology

In collaboration with the U.S. Department of Transportation, Connected Wise has developed a machine vision communication technology to support connected and autonomous vehicles particularly on rural highways.

Machine Vision Communication

Connected Wise's Infrastructure-to-Vehicle (I2V) communication technology comprises of smart traffic signs with unique visual identifiers and an on-board machine vision system. When the machine vision system recognizes these identifiers, it activates the I2V messages containing important roadway and traffic information such as operational messages, safety warnings, and accurate roadway geometry data.

When a CAV equipped with the Connected Wise's machine vision system sees a smart traffic sign, it will match the sign identifier with an I2V message from the preinstalled library.



Transportation Applications

- Work zones, detours, road closures, and geometry changes.
- Unsignalized traffic intersections, lane merges, and pedestrian crossings.
- GPS/GNNS unavailability, positioning and navigation applications.
- Ideal for rural area I2V applications

The proposed system has superior advantages over using a matrix barcode system (e.g., QR code) as it performs image feature matching instead of simple message decoding.

The System can operate robustly under challenging environmental conditions such as glare, night-time, rain, snow, fog, and partial obstruction by an object.

Deployment Scenarios

Scenario A: Autonomous Vehicles

Objective : Improve autonomous navigation of Small Multipurpose Equipment Transport (S-MET) vehicles in GPS denied environments.
Help these vehicles maintain PNT in isolated military bases when GPS signal is interrupted, spoofed, or not precise.

Product : Fully compatible software integration with military RAS platforms. The software system will meet all technical requirements mendated by defense agencies. The system uses the existing hardware capabilities in the autonomous vehicle.

Scenario B: Driver Operated Vehicles

Objective : Tackle PNT challenges for driver-operated military vehicles. Provide accurate and secure positioning data on the daily routes of military vehicles transporting equipment and material between the bases.

Product : A low-cost onboard machine vision device adapted for military applications. The product is equipped with sophisticated artificial intelligence technology and the unique capability to recognize invisible mapping identifiers on the road.

Current Stage of Development

The U.S. Department of Transportation Volpe Center ranked the commercialization readiness level of the proposed machine vision technology as 7/9 (i.e., Prototype demonstrated in an operational environment). Connected Wise will fully adapt this technology for the U.S. Department of Defense requirements in the next 2 years.