Seegrid® Corporation

Vision-Guided Ground Vehicles

Presented to NDIA Ground Robotics Capabilities Conference, August 13, 2014
Outline

- Seegrid Background
- Technology
- Products
- Future Opportunities
Seegrid’s Breakthrough Technology

- Using **stereo cameras**, vehicles equipped with Seegrid’s technology can reliably **navigate** in any **unmodified environment**.

- Uses **statistical analysis** of large amounts of data to provide **robust and reliable location mapping and guidance** for mobile robotic devices and **autonomous vehicles**.

- Leverages commercial sensor and computing technologies to ensure **continuous performance improvements**.

- **WalkThroughThenWork®** simplifies deployment
Extensive experience in robotics, automation, software, manufacturing, warehousing and logistics

- 2003 spin-off of renowned Robotics Institute, Carnegie Mellon University (CMU)
- Seegrid Co-Founder and Chief Scientific Officer, Dr. Hans Moravec
- 35+ years of development under Dr. Moravec
- Designer and manufacturer of the world’s FIRST and ONLY vision-guided automated guided vehicles
- Strong and experienced management team
- 40 International patents
The Business Imperative

- Labor represents 70-80% of total operating costs
- Different shifts and employee downtime lead to operating inefficiencies
- Employee related accidents lead to downtime and increase in workman’s compensation claims

$30/hour $3/hour

- Reduce labor costs (in certain applications, 90+%)  
- Minimal downtime leads to improved operational efficiency  
- Improvement of safety associated with robotic vehicles

Full payback in 4-15 months based on utilization
The Big Benefit: Vehicle Labor Reduction

- The operator accounts for >72% of the total operating cost
- Dramatically reduce the cost of material movements
- Stay competitive in business environments with rapidly rising labor costs

Vehicle Ownership Costs

- Labor 72%
- Purchase Price 11%
- Maintenance 9%
- Electricity 5%
- Interest 3%
Seegrid Products

- Flexible AGV’s
- Vehicle Navigation Kits
- Vehicle Navigation Controllers
- Stereo Ranging Cameras
- System and Fleet Controllers
Robotic Industrial Trucks

- GT3 Tow Tractor
- GP8 Pallet Truck
- GP8 Towing Attachment
- S-KIT
- GT10 Tow Tractor
- Linde P50C
- GWS35
- Raymond Courier
- Yale MO50T

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Walk or drive AGV through desired route

AGV camera takes 360° images of facility, builds 3D map

Operator loads pallets or attaches carts

Operator enters trained route and activates the “Push to Work” button

AGV travels on pre-trained route, delivers goods, and returns for more work
S-Kit: Common Autonomy Platform

Standard Manually Operated Industrial Vehicle +

Vision Guidance Unit

Graphical Operator Interface

Vehicle Interface Module

Power Distribution Module
The Core Technologies

TECHNOLOGY

- Stereo Vision Sensing
  - Captures large data sets quickly – can range 100’s of points/second
  - Software centric

- 3D Evidence Grids
  - Complex, Compute intensive
  - Compensates for Uncertainty

BENEFIT

- Non-Radiating, Infrastructure-Free
  - Usable in stealth and existing operations
  - Long range, low energy
  - Low cost

- Robust, Adaptable
  - Based on statistics, not heuristics
  - Allows full 3-D modeling

Leverages Moore’s Law
Stereo Ranging Technology

Software Stack

SYNCHRONIZED IMAGE CAPTURE

- Imaging Control
  - Exposure Adjustments
- Camera Distortion Correction
- Relative Camera Position Application
- Baseline Correction
- Feature Selection
  - Choice of Ranging Rays
- Feature Matching
  - Determine Stereo Disparity
- Feature Projection
  - Comm. Layer

Identified Feature

Distance to Feature
3D Probabilistic Modeling Technology

Managing imprecision and uncertainty to provide accurate representations

Range Data Uncertainty

- cone width
- height
- range uncertainty
- angular uncertainty
- rise slope
- fall slope
- beam angle drop-off
- depth

Turning Point Clouds into 3D Maps
Technology in Action

Flexible AGV Traveling

Captured Stereo Data

Flexible AGV View
Seegrid Benefits

- **Flexibility**
  - No infrastructure required for navigation: no wires, lasers, tapes or magnets
  - Scalable
  - Quickly modify and change routes as needed
  - Operational in both manual and automatic modes

- **Safety**
  - Eliminate costly employee injuries
  - Zero product damage
  - No facility and equipment damage

- **Affordability**
  - Reduce labor, operating, and maintenance costs
  - Rapid return on investment
  - Low total cost of ownership
  - Eliminate dependence on seasonal staffing and temporary employees

- **Efficiency**
  - Reduce long and inefficient manned travel
  - Operate 24/7
  - Operational from day one
  - Quick uptime improves productivity immediately
Future -- Automotive

- Obstacle Avoidance
  - Warning, Active Control
- Augmented Control
  - Simplified Driving
- Autonomous Functions
  - Parking, Retrieval
- Autonomous Driving
- Embedded Design
Future - Defense

- UGV Capability Modules
  - Robot Return, Targeting, Operator Augmentation, Autonomy
- Convoy Clearance
- GPS Denied Navigation
- Personnel Localization
- Threat Location
Future - Security

- Perimeter Monitoring
- Threat Identification
- Access Control
- Airport and Port Security
- Sensitive Facility Security