Dynamic Positioning Committee

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Sensors SESSION

Laser Target Ambiguity

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Abstract

The problem of target ambiguity for local position reference systems is described. We trace the history of local position reference sensors as they have sought to reduce the risk from target ambiguity, moving from early staring laser sensors to continuously rotating laser sensors. We take a look at how microwave position reference sensors deal with the issue. We then take a look at developments on the reflector side of the system, with increasing adoption of prism reflectors. We describe the principle of operation of the dichroic reflector. We report on recent results with the CyScan Absolute Signature system, and show how it will entirely remove the danger of laser target ambiguity.

Introduction

With the current generation of local position reference systems, one or more reflectors are installed on an oil rig or other fixed installation. A scanning sensor is installed on the ship. The sensor is able to measure range and bearing to each of the reflectors. The position of the installation relative to the vessel can be derived from these ranges and bearings. Provided that the range and bearing to at least two reflectors can be measured, the system can also derive the orientation of the rig relative to the vessel.

Staring laser sensor

In the earliest laser position reference systems [1], the laser sensor scanned around the scene until it found a reflector. The sensor then controlled its orientation to stare at the reflector. The sensor then delivered an accurate range and bearing to the reflector. This worked well provided that there was only one reflector and that a clear line of sight from the sensor to that reflector was maintained at all times. But difficulties could arise if there were other shiny surfaces on the rig which could reflect the laser beam in a similar way to the installed reflector. The fault behaviour could manifest either at start up or in response to occlusion.

Start up

The laser sensor can detect a number of reflective objects. The user is required to resolve the ambiguity by selecting the reflectors to be tracked. It is not always easy to associate reflections on the screen with reflectors on the rig.

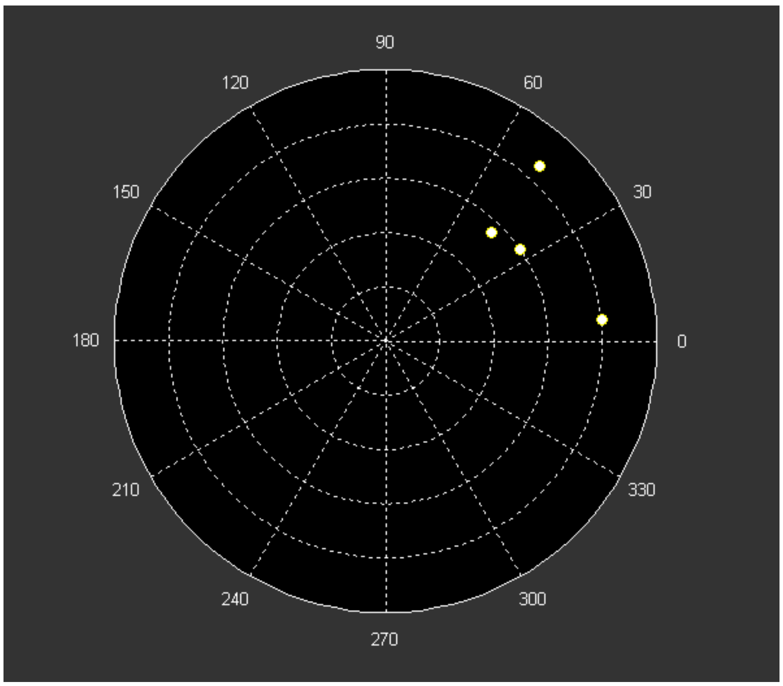


Figure 1: Initial Scan

Occlusion

If the selected reflector is obscured, a staring sensor will lose angle feedback. If the vessel is in motion while the reflector is obscured, the sensor won't necessarily be looking in the right place when the obscuration is over. Consequently the laser sensor is programmed to scan through a search sector whenever it loses sight of the selected reflector. This doesn't always end well – it can lock on to another reflector.

Target swap

When another reflector moves in front of the selected reflector a staring sensor will tend to lock onto the other reflector and follow it as it moves away.

Continuously rotating laser sensor

The introduction of continuously rotating laser position reference systems was an important step forward [2]. In these systems the laser scans across the scene at a constant rate. It is able to measure range and bearing to all of the reflectors in the scene once per revolution. This offers some important defences against false reflections.

Reflection profiling

An intentional reflector gives a consistent profile of intensity against angle as the laser beam scans across it. We can compare the measured profile against the expected profile and reject any reflections which don't match any of the known reflector types. This can help us to reject reflections from extensive shiny objects and from mirror surfaces.

Start up

A continuously rotating laser scanner delivers a fresh view of the whole scene at a high rate. We can use temporal filtering to suppress reflections which don't appear on every rev, or which look very different from one rev to the next. This reduces the clutter and simplified the task of selecting the correct reflector at start up.

Occlusion

We can deploy 2 reflectors to give some resilience to occlusion of one of the reflectors. We can maintain position feedback during an occlusion. And once the occlusion is over, we can test that the separation of the reflectors matches. This enables us to reject the substantial majority of incorrect associations after occlusion. The test is even stronger with 3 reflections. Only a reflection which is in the correct relative position to the other two will be accepted after an occlusion.

Target swap

A continuously rotating laser scanner offers some extra defence against target swap even when used with a single reflector. We might still switch our attention to the confounding target when it moves in front of the selected reflector, but as it moves away, the original reflector will become visible and remain visible, making it possible to detect and correct the association error.

Coded reflectors

The first decade of the 21st century saw the advent of microwave position reference sensors [3]. These sensors modulate the returned signal and (in the case of RadaScan) rotate the polarisation which serves to make the reflection very distinctive compared to anything else which comes back from the natural scene. This renders false reflections practically impossible.

Laser local position sensors have lagged behind radar systems in terms of clutter rejection. To reduce the risk of target ambiguity, we need to make the reflections from our intentional reflectors distinctive compared with those from naturally occurring reflective surfaces.

Improving contrast

Simply by making the reflections from intentional reflectors brighter, we can make it easier for laser position sensors to reject clutter. Recently the industry has been moving away from tape targets to prism cluster targets.

Tape Reflector

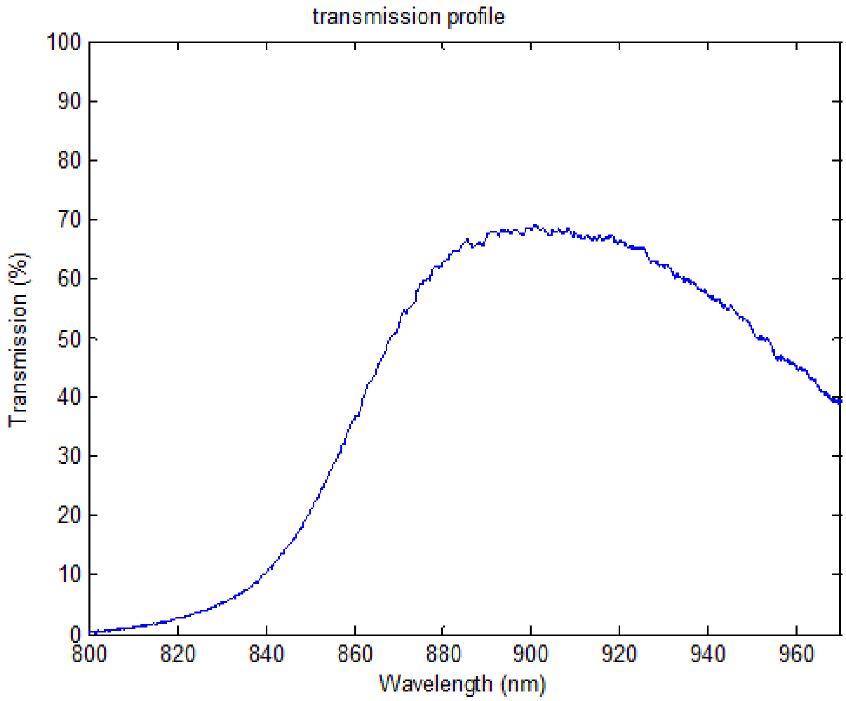
Prism Reflector

Dichroic reflectors

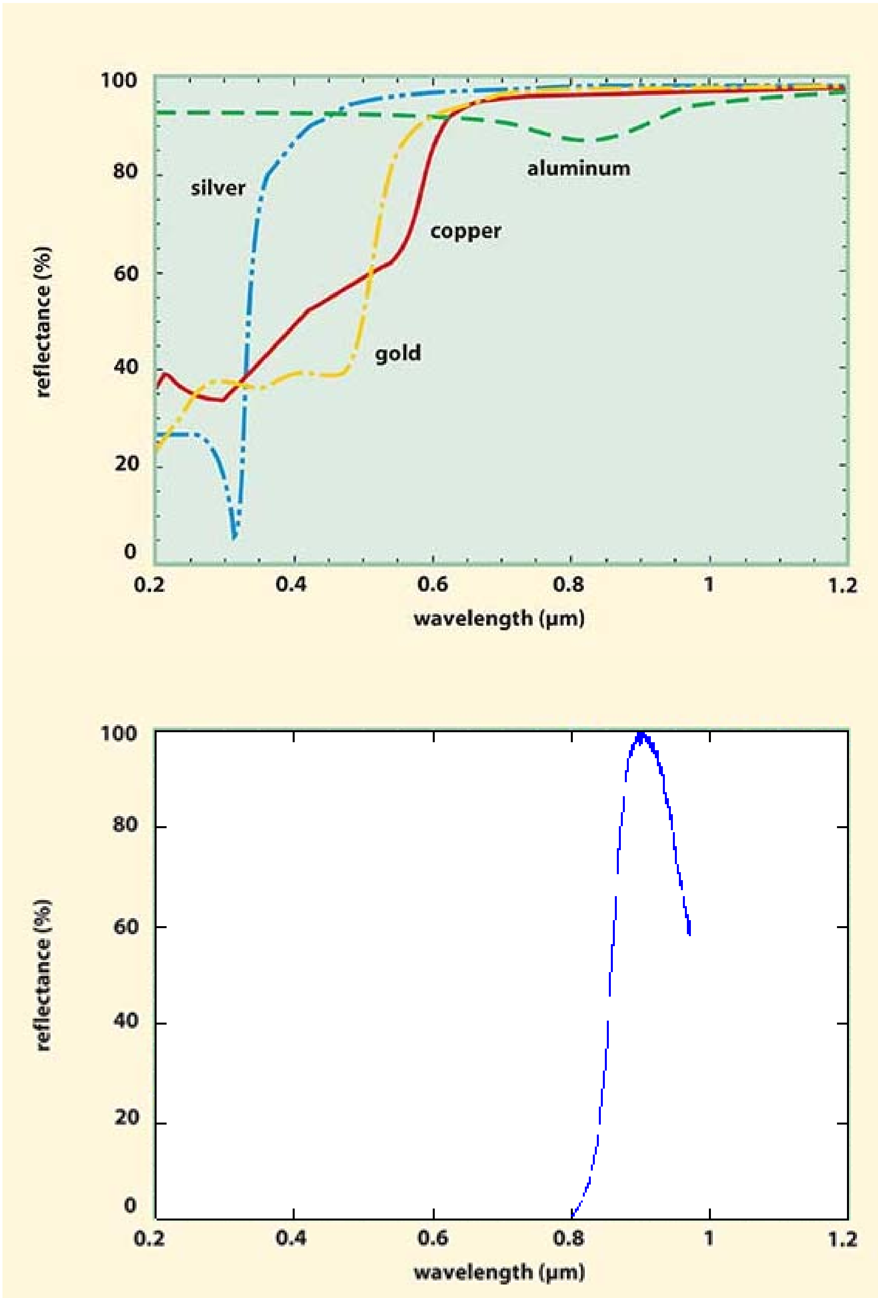
A technique has recently been proposed which will make the reflections from reflectors highly distinctive [4]. An optical filter is applied to the retro-reflector. At the infra-red wavelength traditionally used by laser position reference sensors, this filter is transparent. So for existing laser sensors these reflectors work just as well as existing prism reflectors. But at a neighbouring infra-red wavelength, the filter is almost entirely opaque. When the reflector is illuminated by a laser sensor which can switch between these two wavelengths, the contrast between the reflections at those two wavelengths is very strongly distinctive against any other reflective surfaces. When used together the dichroic reflector and dual wavelength laser sensor gives complete suppression of all reflective clutter.

Wavelength dependence

We found a infrared filter material for which the transmission changes very rapidly as the wavelength varies between 800nm and 900nm. We measured its wavelength response with a spectrometer:



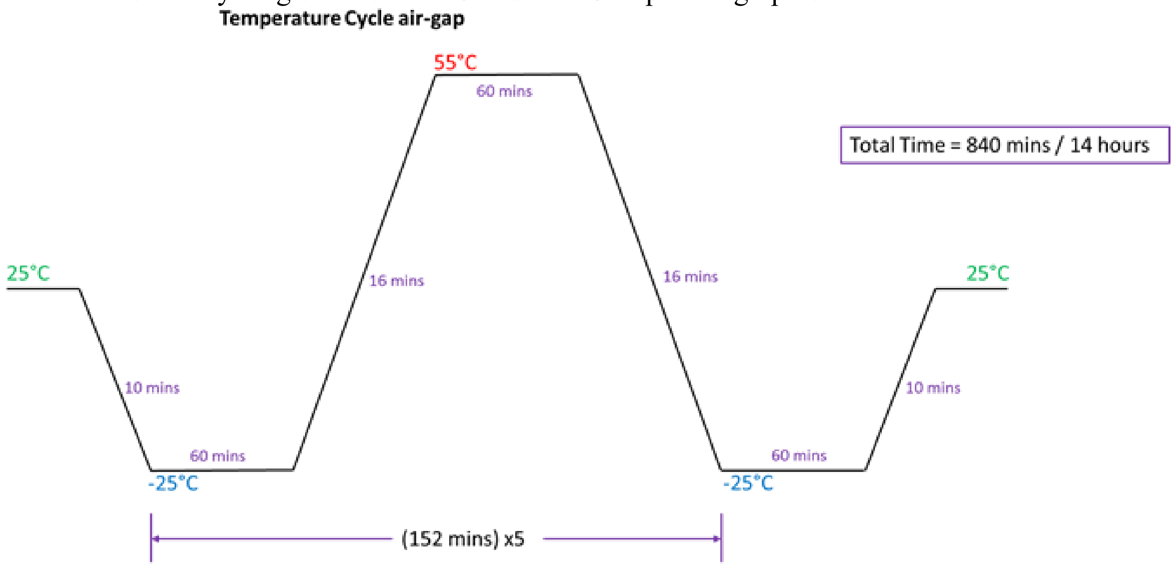
Many of the most prominent reflections found in the typical working environment come from metallic surfaces, either plane or cylindrical. There is little variation in reflectivity in the 800nm to 900 nm region.



Stability of filter

We then put a set of samples of the filter material through a set of increasingly severe thermal stress and retested the transmission properties.

1. Overnight at 40°C.
2. 70 hours at 50°C and 100% humidity
3. Thermal cycling between -25°C and +55°C as per the graph below:



4. Weekend at +70°C

We found no change in wavelength selectivity of the filters.

Thermal testing of the AS prism assembly

References

[1] Fanbeam 4.2 Combined installation, technical and operations manual, 2007.

[2] CyScan: The Benefits of Multiple Hypothesis Tracking for Laser-Based DP Reference Sensors, J Grothusen, DYNAMIC POSITIONING CONFERENCE, November 15-16. 2005

[3] Modulated Microwave Position & Heading Reference Sensor, Jan Grothusen, DYNAMIC POSITIONING CONFERENCE, September 16-17, 2003

[4] GB1501154.7 - Position reference sensor, McKnight and Miles, July 2016