Combatant Watercraft Performance and Maneuvering Telemetry Analysis (Measuring the Diameter of a Pretzel)

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Category
Communications/Signal Processing

Products Used
LabVIEW 7.1
LabVIEW State Diagram Toolkit
NI USB-232-1

The Challenge
The challenge was to develop a versatile laptop-based application to automate the acquisition and analysis of data used to evaluate and characterize combatant watercraft used by the various branches of the US military.

Figure 1. Maneuvering Test

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Data Science Automation was selected to improve test capabilities through automation to quantify performance characteristics of hull, electrical, mechanical, and propulsion systems. The versatile system needed to address the diverse range of watercraft from 14' rubber inflatable rafts to 250 ton surface effect ships, and from 170' coastal patrol ships to hydrofoil troop transports. See Figure 1.

Some of the specific measurements included craft weighing, propulsion system performance, dynamic trim, fuel consumption, and craft speed, control and maneuverability. It is to the last of these – craft speed, control and maneuverability – that this description pertains.

Originally, these physical characteristics were measured during live on-water trials using manual testing and analysis procedures. The demands of testing a vessel in potentially rough waters, the expense of repeating performance trials, and the intense labor/time involved in the manual data collection and post-processing forced the following automated system requirements. The solution needed to be portable, self-contained, fault-tolerant, and require minimal user interaction. It needed to share GPS readings with commercial navigation software, perform integrated post processing of the data including the adaptation of shore-based GPS analysis procedures.

The Solution

The shore-based analysis procedure is the standard method of evaluating the "Tactical Turning Diameter" of a vessel after first correcting for set and drift. This was described by one of the in-house experts as "measuring the diameter of a pretzel" (see Figure 1-B). Previous methods of evaluating these characteristics required considerable effort, skill and patience to prepare the data for analysis using complicated spreadsheet files.

A new, turnkey solution was developed to automate the process using LabVIEW 7.1, the State Diagram Toolkit, and the NI USB-232-1 adapter, installed on a laptop and interfaced with a set of battery powered data acquisition devices. The NI USB-232-1 was selected because it did not require an external AC adapter and was a critical component in the application (see below). NI-VISA was used to control and monitor the serial port during the tests.

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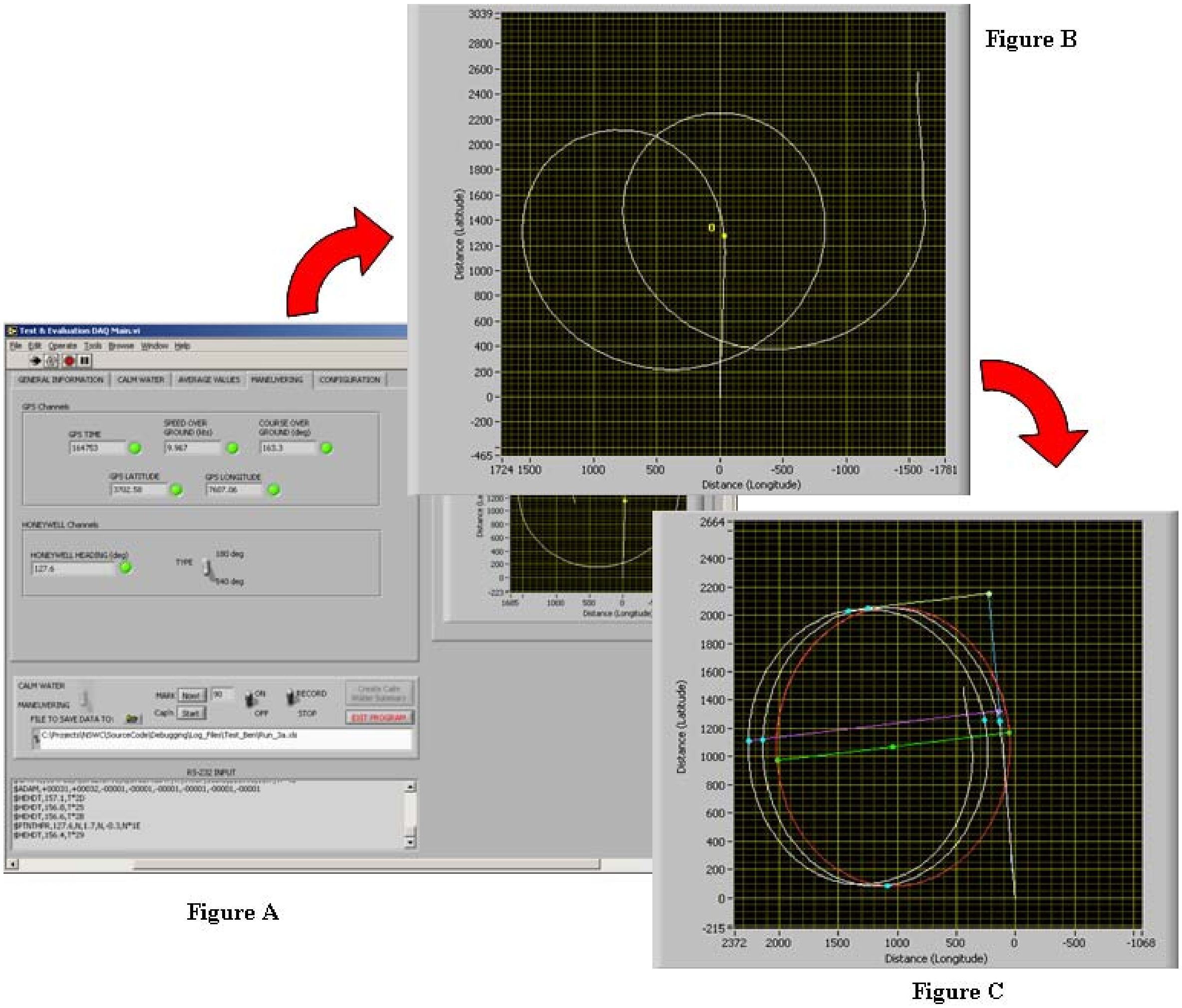

Figure 2. Determining Tactical Diameter, A) User Interface, B) Raw Track (Pretzel), and C) Corrected Plot

The complexities associated with developing a fault tolerant application were addressed at design time. The application's fault tolerance was implemented at multiple levels to address a wide range of failure scenarios, including loss of electrical power, safety hazards, etc. The LabVIEW State Diagram Toolkit allowed us to consider and account for failures ranging from defective sensors and loss of satellite feeds, through to complete sub-system failures. A secondary benefit of using the LabVIEW State Diagram Toolkit was that fault scenarios that were not anticipated at design time could be quickly and easily integrated during development. The resulting client-server architecture was implemented as an event structure to support the user interface and to maintain state and status of each sub-system.

Since a separate GPS antenna for each system was not desirable, the GPS feed for tracking craft location had to be available to a standard laptop based navigation package that was concurrently running on a separate PC from the LabVIEW application. Any problem that affected the serial port's ability to concurrently support two distinct tasks would render the system useless.

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Supplying the GPS feed to the commercial navigation software while monitoring and logging the updates with LabVIEW was accomplished using a creative hardware and software solution. The hardware involved building a custom serial cable that allowed the serial port's read line to monitor the instrumentation feed while the transmit line was available to drive one of the laptop's serial ports. The software component of the GPS feed-sharing duplicated the valid receive packets and re-transmitted them using the serial port's transmit line. This combined hardware/software approach allowed the LabVIEW application to be developed and tested using computers that did not have the navigation software installed and did not require any modification of the same.

Minimal user activity was critical, based on the challenging test conditions encountered. An operator could not be relied on to interact with the application when safety concerns demand their attention or action. Minimizing user interaction with the application was addressed in each of the three phases (Setup, Collection, and Analysis) of a typical test run.

A large number of test condition parameters are logged with the data acquired during each trial. Most of this information is known by operators prior to the date of the test. Therefore, all configuration information could be selected/entered during Setup, in advance of system deployment to the vessel under test. Then, at the time of the test, the operator needs only to load the appropriate header file.

User interaction during the Collection phase of the maneuvering tests was of considerable concern. During maneuvering trials, the position of the vessel needed to be noted each time the craft's heading had rotated a multiple of 90-degrees from the approach heading, a process called "marking." An automatic marking algorithm was implemented that required only the beginning of the turn be marked. The automatic marking allowed the operator to concentrate on surviving what could be a seventeen-second 540-degree turn in rough waters. The results of the automatic marking are illustrated by the blue dots shown in Figure 1-C.

Integrated post processing allowed the operator to review the results of each trial immediately after the trial was completed. The analysis phase of a trial run implemented the automatic marking algorithm and corrected the recorded vessel's track before making the required measurements (see Figures 1-B and 1-C). Figure 1-B shows the raw track of the craft plotted as displacement from the execute point, which is marked by the yellow dot labeled "0". The plot illustrated in Figure 1-B clearly illustrates the "pretzel" shaped track that was traced out by a vessel executing a 720 port turn. Figure 1-B illustrates how set and drift effectively shifts the center of the circle traced out by the craft. Figure 1-C illustrates the results of the post processing. The white trace shows the track of the craft after the set and drift components of its motion have been removed.

Summary

The creativity of the DSA engineers and the versatility of the NI products made this project a unique success. Considerable time and money are saved during each test, safety is improved, and more accurate combatant watercraft maneuverability results are produced. In comparison with the manual post-processing method that would require days to evaluate, and even longer to reschedule the necessary resources if retesting proved necessary, the automated analyses made it possible to make that determination right away, causing a significant improvement in productivity.

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