Autonomous Water Quality Probing Platform

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ABSTRACT

The rapid advancement in drone technology has paved the way for the development of autonomous water quality probing drones. These drones are equipped with sensors to monitor water quality parameters while autonomously navigating between predefined waypoints. Ensuring accurate positioning is crucial when collecting data over a time period as each sample should be taken from the same place every time. This study investigates the positional accuracy of an autonomous flight, comparing the predicted flight path with the recorded data.



Folding 680mm quad copter with 17 inch folding blades and a 6S 10Ah battery

OBJECTIVES

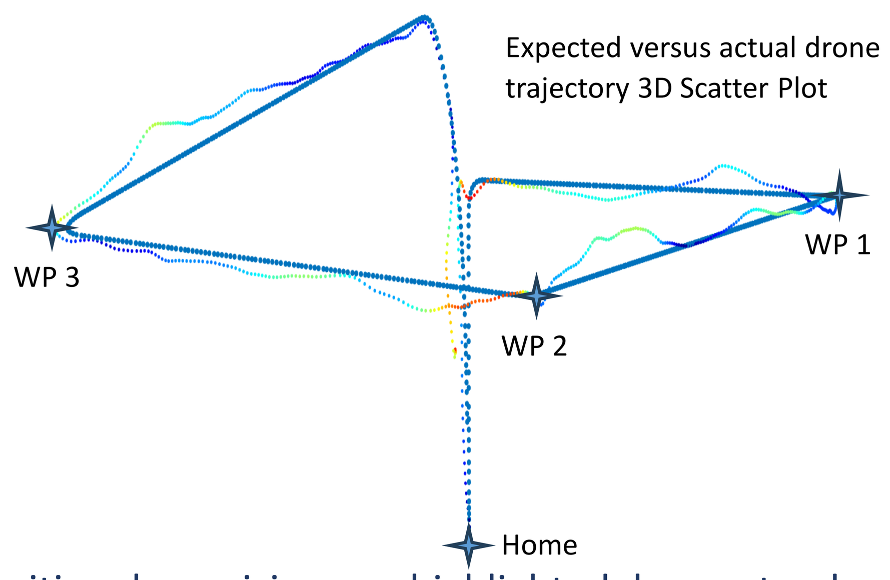
- Design and build an autonomous drone capable of collecting temperature and depth data in a range of reservoirs up to 10 meters deep automatically.
- Setup the platform to automatically upload any collected data with the associated GPS and date / time information to a server for easy access and analysis.
- Process the collected data to measure the systems accuracy and repeatability.
- Develop a data dashboard to process and present the information collected in a visual way

RESULTS

Many test flights were undertaken in various weather conditions. However, the results below are focused on an autonomous flight from a home position to three waypoints in a square at an altitude of three meters. After flying past the last waypoint the system climbed to five meters before landing within centimetres of its starting location.

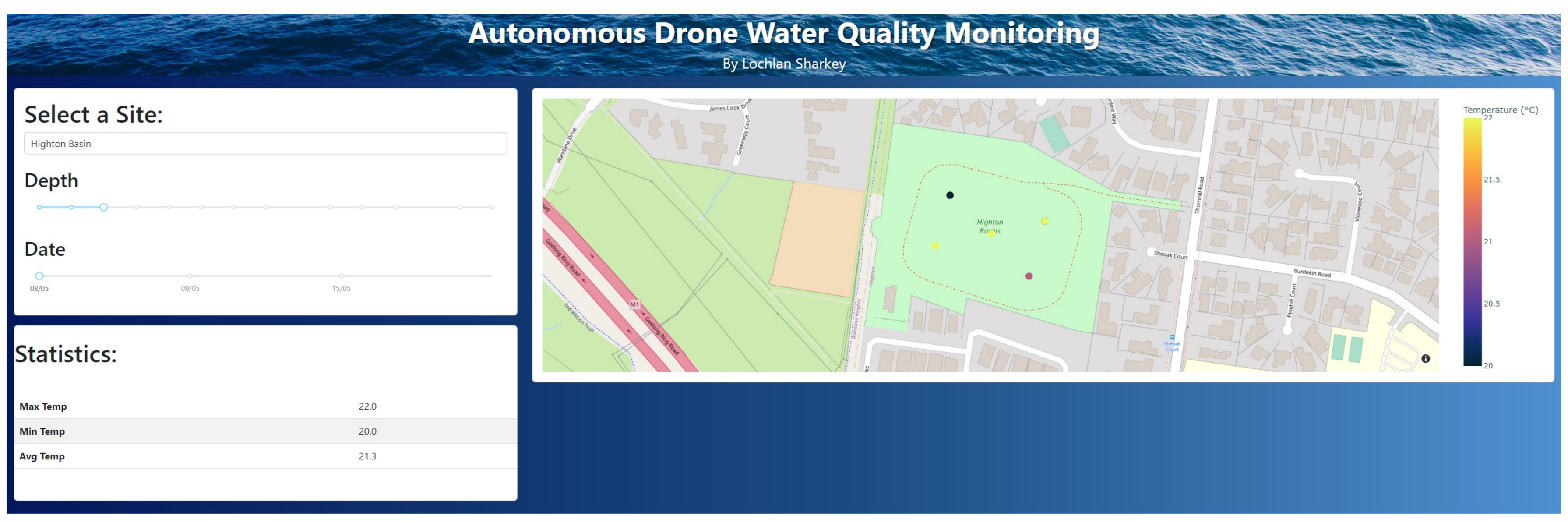
POSITIONAL ACCURACY

	X	Y	Z
Max Difference	37.5 cm	45.9 cm	48.6 cm
Sigma	10.8 cm	14.7 cm	10.5 cm
RMSE	13.5 cm	15.2 cm	10.7 cm
MAE	10.2 cm	10.5 cm	7.7 cm
RMSE-MAE Ratio	32%	45%	39%



The test flight displayed shows notable positional precision as highlighted by a standard deviation (Sigma) of less than 15 centimetres in each axis. This suggests a tight match between the expected and actual trajectories as shown in the 3D Scatter Plot above. The root mean square error (RMSE), with its quadratic scoring, and the mean absolute error (MAE), with its linear evaluation, provide insights into potential causes of deviations. The fact that the RMSE is 32% to 45% greater than the MAE indicates that specific large disturbances, rather than consistent minor inaccuracies, affected the drone's path. Such variations in the positional accuracy could be attributed to gusty and erratic winds from the southwest during testing as reinforced by the greater horizontal deviations shown in the X and Y axes.

DASHBOARD

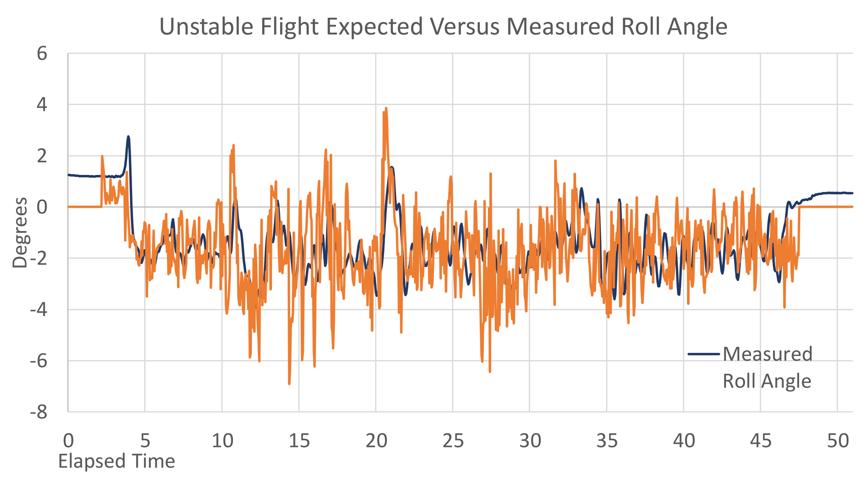


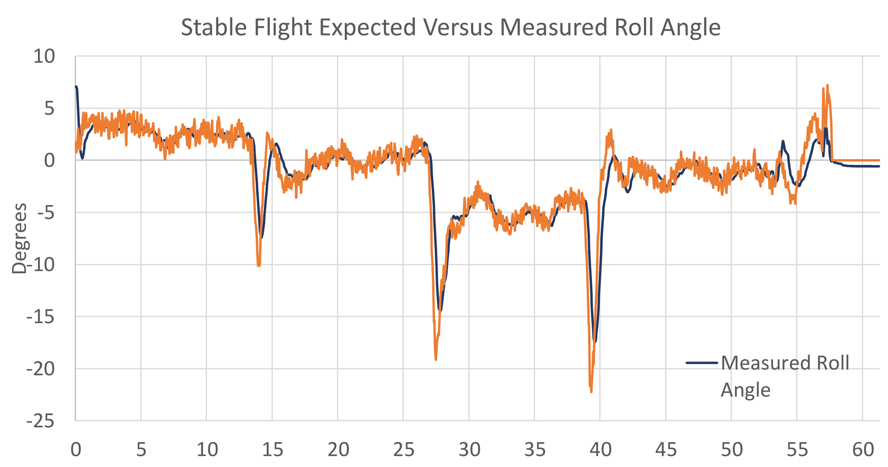
The dashboard created provides users with an intuitive interface to navigate through the historical water temperature data from various missions. By selecting specific sites, dates, and depths, operators can seamlessly track temperature fluctuations throughout their business. By offering a comprehensive view of a water body's thermal dynamics over time some statistical analysis can be used to measure any water stratification and estimate relevant water quality parameters.

ACKNOWLEDGEMENTS

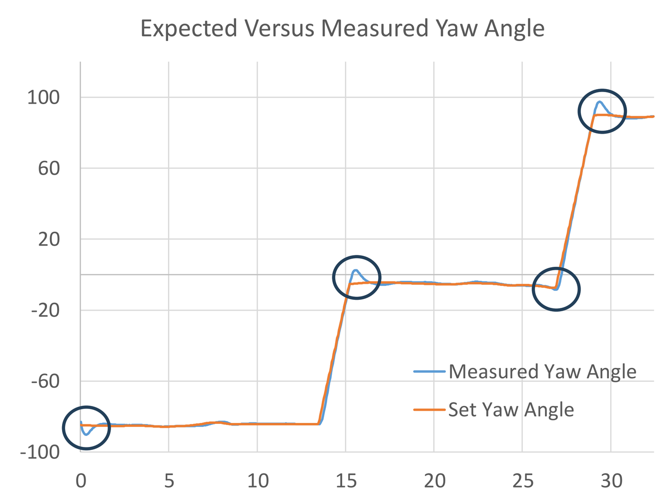
Thank you to Michael and the team at Barwon Water for helping make this project possible.

VIBRATIONS





The orientation data collected highlights the drone's exceptional vibrational stability, confirming consistent performance throughout a number of test flights. A Standard Deviation under 2 degrees across all axes clearly indicates a tight alignment between the anticipated and actual orientations experienced during each flight.



Delving deeper into the data collected, the yaw MAE stands out as it is under half the associated RMSE value. This is likely due to the actual yaw closely following the predicted yaw throughout the flight but suffering due to overshoot when the making a sharp turn as highlighted by the blue circles.

Overall, each axes RMSE value is less than 2 degrees which emphasises the system's dependable capability to sustain its intended orientation in somewhat erratic conditions.

	Pitch	Roll	Yaw
Max Difference	7.12°	11.63°	7.81°
Standard Deviation	1.78°	1.82°	1.83°
RMSE	1.79°	1.82°	1.83°
MAE	1.21°	1.09°	0.89°
RMSE-MAE Ratio	48%	66%	105%

COMPARISIONS

1.SPLASHDRONE 4

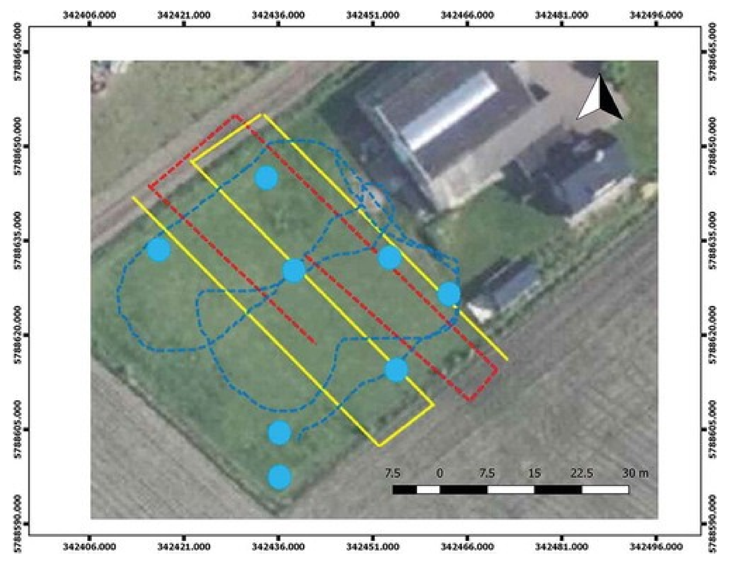
Project Drone Average Waypoint Accuracy: 16.54 cm

Splashdrone 4: Up to 1.1m

The project solution consistently outperforms the Splashdrone 4 in terms of positional accuracy across all axes, ensuring more precise data collection for water quality analysis.

2. RTK Performance Comparison

In a comprehensive study titled "Accuracy assessment of real-time kinematic (RTK) measurements on unmanned aerial vehicles (UAV) for direct geo-referencing," Desta Ekaso, Francesco Nex, and Norman Kerle presented a range of statistics. [2] During their test flight shown in blue a mean XY error of -11.0 centimetres and a vertical, Z error of -26.4 cm was measured. Likewise, a standard deviation and RMSE of approximately 30 cm was calculated in the XY axes with an impressive standard deviation for the vertical axis at 6.4 cm.



	XY	Z
Mean	-11.0 cm	-26.4 cm
Sigma	26.6 cm	6.4 cm
RMSE	31.0 cm	27.2 cm

While both studies emphasise the precision and accuracy of UAVs in geospatial data collection, our results indicate better consistency with a much smaller standard deviation and RMSE measured. However, the journal's findings provide a broader context, emphasizing the potential variability in UAV performance based on equipment, payloads and environmental factors.

CONCLUSIONS

In pursuit to design and develop an autonomous drone for collecting temperature and depth data in reservoirs up to 10 meters deep, we successfully achieved three of four objectives. Currently, the system can autonomously gather data and seamlessly upload it to a google sheet for analysis in the dashboard. Likewise, the system has showcased a high degree of precision in both its flight path and orientation with only minor deviations. However, unfortunately there was not enough time to safely integrate and test the probe using a live body of water. Overall, the drone's performance indicates its reliability and effectiveness for tasks that require precise navigation and orientation with possible future iterations and calibrations that would allow for real testing over reservoirs.

REFERENCES

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