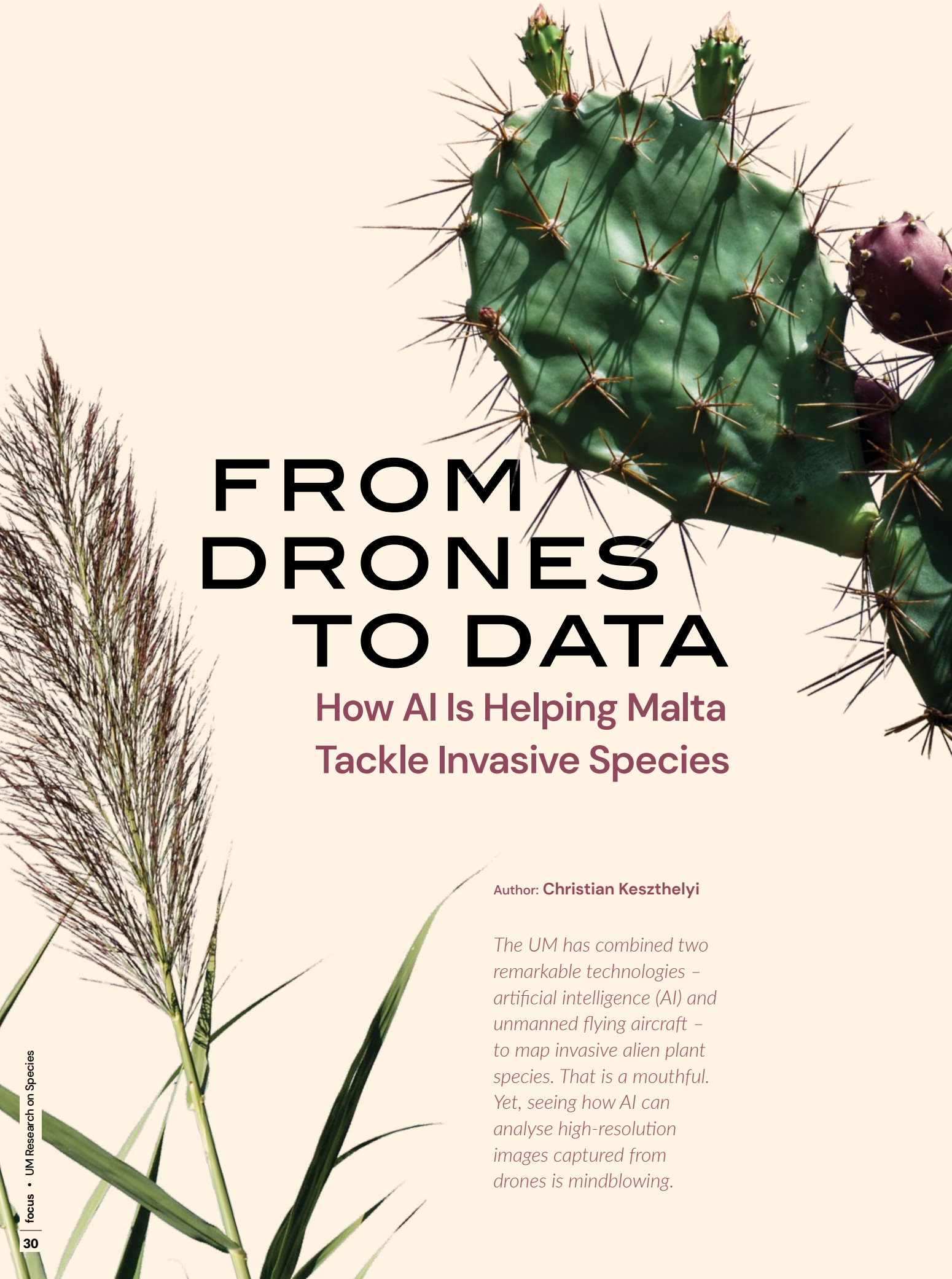

FROM DRONES TO DATA

How AI Is Helping Malta Tackle Invasive Species

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The UM has combined two remarkable technologies – artificial intelligence (AI) and unmanned flying aircraft – to map invasive alien plant species. That is a mouthful. Yet, seeing how AI can analyse high-resolution images captured from drones is mindblowing.

Bang in the middle of the Mediterranean Sea, Malta is locked between Europe and Africa with its own geographic ecosystem. However, domestic flora and fauna have been under duress due to the introduction of invasive alien animal and plant species that disrupt local ecosystems.

The Louisiana crawfish, likely released into Malta's Chadwick Lakes as discarded pets, prey on native frogs and their eggs while competing with indigenous species for resources, threatening local aquatic life. At the same time, the Asian hornet is a growing concern on land. These aggressive predators threaten biodiversity, crop yields, and natural vegetation by preying on the native honey bees essential for pollination and agriculture. Their rapid reproduction makes control and eradication difficult.

Plants can cause equally severe disruptions to the island's ecosystem. Therefore, the UM teamed up with Ambjent Malta, a government entity tasked with preserving and enhancing Malta's natural capital and biodiversity, to map plants that are foreign to Malta and understand their impact on the local ecosystem. The Malta Information Technology Agency, the government's IT agency, funded the project.

'Ambjent Malta was particularly keen to tackle invasive plant species, which often spread through discarded seeds or plants and outcompete native flora. The proposed solution centred around deploying a drone equipped with a high-resolution camera to survey local valleys and capture the images. Then, using artificial intelligence, we would detect and map the invasive species,' Prof. John Abela from UM's Department of Computer Information Systems tells **THINK**.

DISRUPTING LOCAL ECOSYSTEMS

Invasive plants outcompete native species for sunlight and nutrients, eventually dominating the environment and leaving little room for indigenous plants. This disrupts domestic ecosystems, as native plants often provide food and habitat for local wildlife, affecting the entire food chain.

'The issue underscores how human actions, such as releasing pets into the wild or unintentionally importing species, can have long-term and wide-reaching consequences on biodiversity,' Abela says.

But why would humans introduce alien plant species to their homeland? There can be many reasons, often practical. Malta's well-known prickly pear was intentionally planted along field edges to protect crops from wind damage. While it served this purpose effectively, it eventually began competing with native species. Similarly, many invasive plants were imported as ornamental garden additions. Over time, their seeds were dispersed by the wind, spreading uncontrollably and encroaching on local ecosystems.

'Before addressing the issue, it's crucial to understand the extent of the problem. This is where our project plays a key role. By mapping the locations and spread of invasive plant species, we provide a clear picture of their distribution. Annually monitoring these species enables us to track changes over time, identifying whether their populations increase or decrease,' Abela says.

The project began with a drone survey of 37 valleys selected by Ambjent Malta, capturing high-resolution aerial photos of plants. These images were then stitched together to create a mosaic. A trained biologist at Ambjent Malta then reviewed the images to identify and label invasive species. Once identified, the biologist used a tool to outline the invasive plants in each image, a time-consuming process that took nearly a year to complete across all 37 valleys.

***Top left*: A typical drone used for aerial surveys**

***Top right*: The *Opuntia ficus-indica* (Bajtar tex-xewk) is an invasive cactus that was probably introduced because the fruit is edible**

***Bottom right*: The *Arundo donax* (great reed) invasive alien reed that has taken over many of Malta's and Gozo's valleys and water courses**

Photos courtesy of the team

TEACHING THE AI

'After labelling, we used open-source convolutional neural network (CNN) models adapted to our project's needs. A research support officer (RSO) with a Masters degree in ICT implemented the deep learning models. While data labelling continued, I worked closely with the RSO to refine the models. We trained the models on mosaics from five or six areas, leaving parts out for testing. This iterative process ensured accuracy in identifying invasive species. At the same time, we wrote custom code to address image noise and anomalies,' Abela says.

The model analyses mosaics to locate invasive species, highlighting them in different colours based on the species. During training, the researchers provided labelled data for the model to learn iteratively.

This process is similar to training a model to differentiate between dogs and cats using 1,000 pictures of each and a smaller validation set of 100 images per category which are not used during training. When the model is given a picture, it outputs probabilities for each class (dog or cat). If the model misclassifies the image, the error is calculated, and the model adjusts its internal weights to improve accuracy.

The analysis and learning steps require significant computing power, as the computers need to run continuously for five to six days in air-conditioned rooms. Once the model optimised its process of differentiating between different flora, it was tested on unseen validation images. When it classified these correctly, the team considered it ready for real-world use.

'AI is invaluable because, unlike traditional programming, it doesn't require complex rules. Neural networks, inspired by biological brains, learn from vast data, automatically adapting and improving. While powerful machines and GPUs [graphics processing units, which are specialised processors designed to handle the complex calculations needed for rendering images and videos] enable training, the biggest challenge is acquiring and labelling data. For our project, this meant painstakingly labelling invasive species in large images – a time-consuming but essential task,' Abela says.

CHALLENGING FEAT

The project team faced some challenges. One of these was that some local plants closely resemble the invasive species. Even a trained human eye, carefully examining high-resolution photos, could sometimes mistake one for the other. To address this, the team conducted field trips to physically verify the species.

Another challenge was refining the models. Although deep learning models are often considered to be general-purpose, their core engine is versatile. Still, significant customisation through extensive coding was needed to tailor

Top*: Ortho-image inputted into ArcGIS showing identified patches of the species *Opuntia ficus-indica

***Bottom*: The red is the coarse grain *Opuntia* label, the purple line is the fine grain**

Images courtesy of the team

the engine for this specific task to suit the project team's needs.

Additionally, plants can look quite different depending on the season, which posed another problem. 'For instance, if you take an image in May, the plant might appear very different in August. By then, much of the green could be gone. After the rains in October and November, the plants would change again. Ideally, to handle these seasonal variations, we would have run the drone surveys four times a year, but unfortunately, the cost of doing so was prohibitive,' Abela says.

Although the project ended after mapping the invasive species, Abela is launching another project to automate the entire process. Now that the team has a robust dataset, they can focus on streamlining operations and improving efficiency, potentially transforming how we monitor and address invasive plant species in Malta.

This shall lead to the ultimate goal of eradication, for which experts need comprehensive knowledge, as strategies and decisions are complex.

'Take the giant *Arundo* reed, for example. This plant grows in waterways and has displaced local flora. However, many local fauna have adapted to use it as breeding grounds. This creates a dilemma: eradicating the reed would help restore native plants but could harm the ecologies now dependent on it,' Abela says.

Ambjent Malta is considering a balanced approach. In some areas, full eradication may restore the original ecosystem. In others, invasive species may be left intact to preserve the adapted ecology. This strategy allows for both conservation and practicality.

The project has appeal – and use – beyond Malta's shores. 'We are planning to move forward with this project, and Ambjent Malta has contacts with the University of Palermo, who are interested in our work. We will likely collaborate with them and share our findings and methodologies, which is especially relevant because Italy faces the same issue. Similarly, France and Spain are also grappling with invasive fauna and flora,' Abela says.

'The key issue, as I often point out, is funding. We would like to move to Phase 2 of the project. This will include using a drone with a multispectral camera, seasonal surveys, and the application of the latest Transformer AI models. This will require funding for equipment and also human resources. While the potential exists, funding remains a significant barrier,' Abela concludes.

Funding for the Detection of Invasive Alien Plant Species from High-Resolution Drone Images project (MITA: C074/20/SOW) was provided by the Malta Information Technology Agency (MITA) in the form of a grant.

The full list of acknowledgements is available on the digital version of the article at thinkmagazine.mt