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From Competition to Collaboration: Automated Identification of Right Whales

Report to IWC SC68B Photo Identification Sub-Committee

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In 2019, the Southern Hemisphere sub-committee welcomed new information on the use of automated identification for right whale photo-identification (SC/68A/SH/WP/12), noting that as this technology develops it may prove extremely useful for future right whale assessments, by reducing the time and cost of inter-catalogue matching. The sub-committee encouraged Khan and colleagues to provide a more detailed update on this topic to the Photo Identification Working Group at SC/68B.This report aims to provide an update to the project and clarify questions raised by the sub-committee last year.

In summary, the NOAA funded collaborative project with Kaggle, Deepsense.ai, Wild Me, and right whale researchers around the world has progressed substantially towards the overall aim to use artificial intelligence (AI) software for photo ID matching of right whales. AI algorithm training was undertaken using 53,266 aerial images of North Atlantic Right Whales from the New England Aquarium database. The algorithm of choice Deepsense.ai is now achieving 88.9% top-1 accuracy and 97.8% top-5 accuracy using high quality aerial imagery. The photo identification software is operational online in the Flukebook platform. Further algorithm training is currently underway using southern right whale images from South Africa, Argentina, Brazil, Australia, and New Zealand. The software is available via the online Flukebook platform for public use for photo identification matching of North Atlantic right whales now and will be operational for southern right whales by the end of 2020 to complete phase 1. Phase 2 includes algorithm training using lateral shots and this will be undertaken during Q4 of 2020.

In regard to the query raised at IWCSC68A, on the 87% success rate reported from the Kaggle winning algorithm in 2019, this represents the top-1 accuracy, which was the number of times that

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the model output the correct whale identification when allowed to output only one result. The model yielded 94.87% top-5 accuracy, which was the number of times the model output the correct whale identification when allowed to output 5 possible whale identifications. Top-1 and top-5 accuracy are commonly used evaluation criteria in machine learning algorithms.

New models were generated using both the Deepsense.ai and HotSpotter algorithms on a more comprehensive subset of the 400,000 aerial images from the United States and Canada curated by the New England Aquarium Catalog, and these new models went live in the Flukebook online platform in November of 2019. Operational usage of the new system is just beginning, and to date we have tracked the success of 130 photographs from manned aircraft and UAS platforms in the system. System performance with a wide variety of image qualities was 61.3% top-1 accuracy and 75.7% top-5 accuracy from the Deepsense.ai algorithm. The performance of the HotSpotter algorithm was much lower at 4.9% top-1 accuracy and 12.2% top-5 accuracy, and so in March 2020, we decided to discontinue the use of the HotSpotter algorithm for North Atlantic right whales. For high-quality photographs, the Deepsense.ai algorithm performed at 88.9% top-1 accuracy and 97.8% top-5 accuracy, meaning that the correct whale was almost always found within the first 5 suggested matches.

This Deepsense.ai algorithm is currently being trained on catalogs of Southern right whales as mentioned in the last report (SC/68A/SH/WP/12): 12,311 images from Australia from Curtin University: 8,461 images from South Africa from the University of Pretoria; 8,952 images from Argentina from the University of Utah; 5473 images from Brazil from Instituto Australis; and 2,913 images from New Zealand from the University of Otago. After filtering for known individuals with at least 2 sightings, the total Southern right whale datasets include 10,451 photographs. These datasets differ from the New England Aquarium catalog significantly in the average resight-rate of individuals: the New England Aquarium data has a mean of 88 training photos per individual while the Southern right whale datasets have only 4. This has resulted in a significantly lessaccurate model; initial tests show a top-1 accuracy of 25.9% and top-5 of 40.0% for the Deepsense.ai algorithm trained on Southern Right Whales. Further funding and research is anticipated to make the algorithm more generalizable so that the Southern right whale model can more closely approach the North Atlantic model in accuracy. Further developments planned for this year include an attempt to expand the capacity of the system to recognize whales from vessel based photographs of the head as well as more challenging body parts such as from the flukes, bellies, and peduncle scars. Other platform infrastructure changes are also underway to make the user-interface more streamlined.



This search engine is connected to the live Catalog database. New whales and sightings of previously cataloged whales are added as soon as the identifications are confirmed.



Figure 1. The redesigned North Atlantic Right Whale Catalog (<u>http://rwcatalog.neaq.org</u>) which includes the option to 'Search for whales using FlukeBook's automated matching system".



Figure 2. The landing page for the FlukeBook platform (<u>https://www.flukebook.org</u>) which applies computer vision algorithms and deep learning to identify and track individual cetaceans.



Figure 3. The page in the FlukeBook platform (https://www.flukebook.org/) where the first algorithm pipeline results are shown. Once a whale is successfully identified in the photograph, a bounding box is drawn over the "passport" photo area in the image containing the head.



Figure 4. Close up of the bounding box drawn over the head of a North Atlantic right whale in the FlukeBook platform (<u>https://www.flukebook.org/</u>).

Matches based on Deepsense AI's Right Whale Matcher 4/20/2020, 1:40:30 PM <i>against 22354 candidates</i> • The deepsense ai algorithm for right whale matching works only on individuals in the <u>North Atlantic Right Whale Catalog</u> operated by the New England Aquarium. This is because it is a pre-trained algorithm that can only identify the whales in its training set. • The matches on this page are preliminary and must be confirmed by the New England Aquarium before they are added to the NARWC.		
1 0.4419 Enc f02986 1250	5 0.0018 Enc 52322d 3705	9 0.0001 Enc.43f4a0 3810
2 0.307: Enc 5254aa 3725	6 0.0014 Enc df3079 3314	10 0.000! Enc ae132c 3310
3 0.096 ⁴ Enc a5c465 1152	7 0.0001 Enc f6b9e4 1425	11 0.000! Enc 886d36 1613
4 0.0178 Enc 112656 2271	8 0.000 Enc 4915f1 1320	12 0.0004 Enc 80eaec 1616
		anonadik

Figure 5. The Deepsense algorithm results on Flukebook showing the 12 most likely matches for the photograph on the left side. In this case, the correct match is shown in position 2 in gray highlighting-- the whale known as egno 3725. The bold number 0.307 indicates the algorithm confidence. In this case, the algorithm was much more confident about the first two suggestions.



Figure 6. The North Atlantic Right Whale Catalog (<u>http://rwcatalog.neaq.org</u>) page for whale number 3725 including composite drawing and exemplar photos. Here we learn that whale 3725 is a female born in 2007 to the mother 1425 and father 1037.