THE USE OF SUBJECTIVE PATTERNS IN GREEN TURTLE FACIAL PROFILES TO FIND MATCHES IN AN IMAGE DATABASE

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INTRODUCTION

Each summer since 1989, we have photographed and videotaped an ohana* of turtles at Honokowai, West Maui, Hawaii. To identify individual turtles, we capture facial profiles and catalog them in a database, as we described in our presentation at the 19th Sea Turtle Symposium in South Padre.[1]

Green turtle profiles feature a relatively small number of facial plates in a limited number of arrangements, yet the variety is rich enough that every animal is unique, at least within our ohana. While some profiles are similar enough to cause confusion when seen or captured at a distance or with low resolution equipment, close examination has thus far always revealed differences. Further, when turtles exhibit similar profiles on one side, the other profile has always revealed differences sufficient to identify the animal conclusively.

Upon encountering a profile (called the Unknown Turtle), the task of comparing it with each one of the 400+ profiles became overwhelming. Clearly we needed a methodology to find quickly whether a matching profile existed in the database.

The Problem

Until recently, it was feasible (but tedious) to compare each potentially new profile with those already cataloged, one by one. During summer 2000, however, our database quickly grew to exceed 400 left profiles and 400 right profiles. (Because left and rights are not always matched, we have arbitrarily chosen to avoid counting a turtle twice by counting only left profiles, so these numbers represent 407 "counted" turtles and 78 "right profile orphans.")

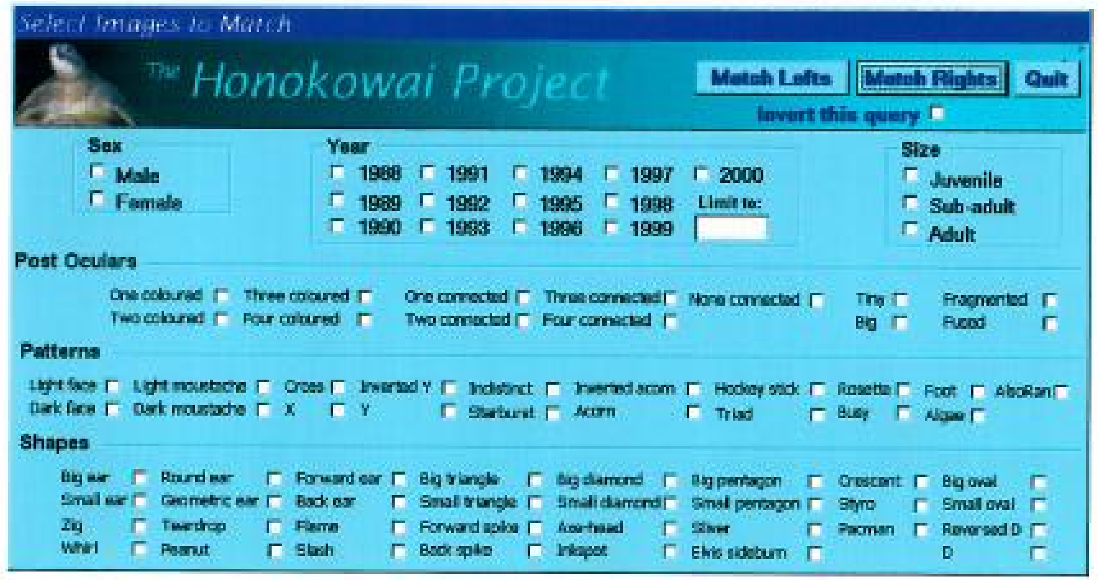
Pattern recognition and matching is a well-explored field with considerable technology in place.[2,3,4] For our purposes, however, existing methods had a significant flaw: implementation would require considerable resources and time. Any adopted technology would have to be integrated into the database structure we already have, or

THE SOLUTION

We realized that most existing technologies were designed to find a single solution: the best possible match. We reasoned that we did not need such a precise result. We therefore looked for a solution that would simply reduce the list of possible matches for the Unknown Turtle to a manageable size--a short list. We could then quickly examine the short list and determine whether the Unknown Turtle was already cataloged.

We based our solution on simple keyword-search techniques. We decided that if profiles in our catalog were described by keywords--plate pattern and shape descriptors--we could produce manageable short lists by searching for combinations. In practice, we found that as few as two keywords could produce useable short lists, and that three or four keywords often returned a single candidate--usually the correct match.

Of course, if the Unknown Turtle was not in our database, it would not appear on any list no matter how short. Although experience has shown repeatedly that an Unknown Turtle that does not turn up on a short list really is not in the database, we nevertheless perform a one-by-one comparison with every cataloged profile. This eliminates the possibility that the Unknown Turtle is in the database but the profile did not include the proper keywords.



This is the selection form used to create the short list of possible matches to the Unknown Turtle. A more sophisticated design (we're working on it) would allow you to select characteristics to exclude as well.

The Implementation

To implement our solution we needed a list of keywords--the descriptive terms for patterns and shapes that appear in green turtle profiles. We realized that while there is value in a standardized list (everyone can grasp what is meant by 'inverted Y' or 'big triangle') the list did not have to be limited to universally understood descriptions.

The reason for this is that there is no harm (minor performance issues notwithstanding) in including a subjective keyword, i.e. one understood only by one person. Anyone who does not understand the keyword can simply ignore it. This accommodates the tendency of each individual to see different patterns and shapes in a particular profile.

Alternatively, anyone can produce a short list of turtles for a keyword that is not understood. By studying the results, you can often grasp the commonality in the profiles and thereby expand your 'descriptive vocabulary'!

These are examples of the characteristic "Big Triangle." Most people will have no trouble seeing this shape with a little study.

These are examples of the pattern called "Triad." Although the name might not bring an immediate pattern to mind, by selecting for "Triad" and studying the resulting list, you might figure out that a "Triad" is a grouping of three plates in a vertical line.

We developed a list of 64 keywords for our use, many of them subjective. For example, terms such as 'big triangle' vs. 'small triangle' leave room for individual interpretation. Indeed, what appears to be 'big' in one image could be interpreted differently in another image, even by the same person. Is this a fatal flaw?

There is a triangle in this profile. Big or small? Well, why not both?

The answer is no. The purpose of a keyword is to make sure a profile is included in a short list. While people intuitively think of 'big' and 'small' as mutually exclusive, in this context they need not be. If there is the slightest doubt which of the two descriptions should apply, our implementation works better if both descriptions are included. Having big triangles show up in a short list that requested small triangles is only a detriment if it expands the list beyond a manageable size. In a database the size of ours, there are simply not enough triangles to turn this into a problem.

The Conclusions

We believe that we have established that facial profiles are a reliable method of identifying green turtles. We have used this identification procedure to monitor turtles over several years, tracking the effects of fibropapillomatosis on individuals. Fortunately, the Hawaiian green turtle, at least at Honokowai, tolerates human presence enough to let us apply these methods and build our database.

As our database grew, however, a pattern matching system became essential. Taking pictures or video is just one small part of the process. The images must be of sufficient quality to resolve potential confusion in identification. They must be cataloged with the history of the turtle, including a description of the effects of the disease. There is little value if they cannot be quickly retrieved, or if it is not possible to determine whether a 'new' profile already exists in the database.

Nui, 1990

Nui, 2000

The 1990 image was captured from Regular 8 videotape, while the image on the right was taken with a DV camera. DV yields high quality images that allow identification that simply was not possible ten years ago, but capturing, analyzing, and cataloging profiles is still time-consuming and often frustrating.

1993 Turtle 11

1991 Turtle 11

These two profiles are similar enough to cause confusion without close examination. Higher resolution and/or closer images would make the differences easier to see, but are often difficult to obtain. The honu's comfort zone must always be respected.

Acknowledgement

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Literature Cited

[1] Bennett, P. A., U. Keuper-Bennett, and G. H. Balazs. In Press. Photographic evidence for the regression of fibropapillomas afflicting green turtles at Honokowai, Maui, in the Hawaiian Islands. In Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation, March 2-5, 1999, South Padre Island, Texas. U.S. Dep. Commer. NOAA Tech. Memo. NMFS-SEFSC.

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* ohana, n. Hawaiian for a group with shared experience. Suggested by George H. Balazs as the best description for the group of turtles we have been observing, as opposed to 'community' or 'population.'