

February 2017 Colin Harvey note to and responses from Erik van den Heuvel, Inspektor Research Systems.

The original note is in black font, and Erik's responses are in red font.

Hi Erik:

Thanks for making time available for our telephone discussion last week, and for your positive response to an invitation to participate in this adventure with VOHC. Thanks for your time too, it was nice to talk to you.

As you go through this note, please feel free to correct any misunderstandings that I might have about technical or other possibilities, or present alternatives that would meet the same desired end result. Although I have had considerable experience with area-measuring software such as SigmScanPro and Klonk Image Measurement programs, my experience does not extend to differentiating depth of color within a designated area.

Here is the list of possibilities that I propose as steps, starting with some clarifications/questions:

Do you currently have software that Inspektor developed in collaboration with Waltham that is designed specifically for scoring of dental plaque in dogs, or was the dog-specific software the result of internal work by Waltham?

The software, including all algorithms, has been built by Inspektor. As stated in my previous mail Inspektor is the sole owner of the software.

Assuming that Inspektor does have dog-specific software in-house:

What level of auto-recognition of the external shape of the target teeth is already in place?

The algorithms in the software discriminate between dental and other oral/facial tissue. Within the dental tissue pixels with enhanced red fluorescence are detected automatically.

The desired end-product of this VOHC project is a system by which use of a QLF camera and licensed dog and cat specific software can be made available for use by veterinary technicians or others with similar animal-handling experience.

Clear.

If the current software does require individual teeth to be outlined digitally by hand, could software be developed that would manipulate an image and present the teeth of interest with digital area demarcations shown on screen, for review/approval by the operator before the software then analyses the target area to score the dental substrate?

The strategy employed by our program is to let the operator indicate the separate teeth. We found that this is (much) faster and easier than assessing and correcting areas generated automatically. At least to the satisfaction of Waltham.

Pet food and pet product companies are keenly aware of the animal welfare considerations in relationship to conducting trials involving live animals, and minimizing or eliminating the need for anesthesia/sedation is a high priority.

VOHC currently requires scoring to be conducted under anesthesia or sedation, except when a designated scoring system pre-approved by VOHC for use in trained, non-anesthetized subjects (such as the GCPI plaque scoring system - *Journal of Veterinary Dentistry*, 24, 14-20, 2007) is

used. The work done at Waltham suggests that a QLF-based plaque score can be obtained in trained, un-anesthetized dogs.

To my knowledge this is correct.

The next step would be to add separate determination of extent of calculus coverage in addition to extent of plaque coverage. I assume this would require either developing a calculus-oriented fluorescence methodology (to prevent the undisclosed non-mineralized plaque-covered area being assumed to be calculus), or brushing away the plaque to leave only mineralized calculus. The extent of the calculus would then be recognized because of natural fluorescence or by using a disclosing dye that adheres to calculus and that fluoresces under QLF. Would brushing away the plaque eliminate the bacteria that fluoresce under QLF?

Brushing would mainly remove the porphyrins generated by bacteria located in plaque. It would not remove calculus. In our experience the red fluorescence of calculus is not affected significantly by brushing so this would be a very feasible strategy. Another line of attack is that the color of red fluorescence in calculus differs from that in plaque but it is yet uncertain if the differences are strong enough to discriminate well between them. Also coloring due to food may be a confounding factor.

Natural dental calculus varies considerably in color, probably due to the colorants added to commercial in dog and cat foods. The Waltham paper on QLF in dogs shows that disclosed plaque may be more practical to use than undisclosed plaque in dogs.

Right.

There is reason to at least investigate possibilities of scoring calculus without disturbing plaque because there are companies that have conducted, and may wish to conduct, trials with intermediate scoring episodes – obviously that is not practical if both plaque and calculus are scored at e.g. day 28 and again at day 56, and plaque is brushed off as part of the Day 28 scoring episode.

Clear, we will have to experiment here and see what works best.

The third step would be to investigate measurement of thickness of plaque (and of calculus) in addition to or separate from extent (% of area covered). Can the depth of color registered in individual pixels within a specified area be measured? My thought is that individual pixel color-density measurements could be combined with the extent of coverage analysis to result in an accurate, objective composite thickness-% coverage score.

The intensity of the red fluorescence signal definitely correlates with the thickness and/or the maturity of the plaque and is part of the measuring technique besides the area coverage.

It may be that the question I sent to you as immediate follow-up to our telephone meeting is a critical issue – what causes the fluorescence when a disclosing dye is used? If calculus with plaque brushed off its surface and stained with a disclosing dye fluoresces well, an intermediate step would be to see if there is a relationship between thickness of calculus and density of the fluorescence.

See the remark directly above.

I would appreciate hearing your comments on practicality of the concepts mentioned above, and, assuming they are worth investigating, what the cost would be for Inspektor to develop the necessary software.

We propose to first get acquainted with the currently available functionality (which already will bring you a long way as far as we can see) and then define desired improvements and assess

their associated costs.

The current VOHC tooth set (eighteen teeth, Maxillary I3, C, P3, P4, M1, Mandibular C, P3, P4, M1 bilaterally in dogs) was selected back in the mid-1990s somewhat arbitrarily – issues such as functional importance, tooth size, ease of obtaining a clear view for scoring and likelihood of plaque and calculus deposition on particular teeth were factors, but no prior analyses were run to determine the optimal set for analysis.

The VOHC tooth set works well when scoring is done by the human eye – the scorer's head can be moved to see the full buccal surface of the upper third incisor, whereas, for instance, a single digital image of the arcade that is taken with the long axis of the camera lens positioned perpendicular to a line from the canine tooth to the carnassial tooth (max P4) does not pick up the full buccal surface of the third incisor.

I have conducted studies of scoring gingivitis and attachment loss using a weighted tooth scoring system, and used those data to show that a limited set of teeth, scored unilaterally, correlates highly with scoring every tooth in the mouth. The sub-set paper is available as a link under Additional Resources on the VOHC Scoring Project webpage I have set up in the VOHC website (http://vohc.org/digital_scoring.html). The sub-set paper is also attached to this note.

Great. Thanks.

I suggest we concentrate the computer programming work on a few large and easily recognized teeth in order to determine whether plaque extent and thickness scoring, and calculus scoring (extent and thickness), are practical.

This indeed might be the best approach, It fits the suggestion done above to first experiment with existing functionality.

While this is underway, I propose that VOHC arranges with some of the companies that have made submissions to VOHC to analyze data from existing trials to determine whether use of the full 'VOHC tooth set' is necessary for a QLF score. Can an easier-to-photograph sub-set produce data that correlates with high significance with data from the full VOHC tooth set, and is bilateral scoring necessary?

This, to us, sounds like a good idea.

One possibility to consider would be to have an Inspektor representative attend the European Veterinary Dental Forum - a session will be included on the VOHC Scoring Project. The Forum will be held in Malaga, Spain on May 19-20, though I do not yet know the specific day/time for the VOHC Scoring Project session. I hope that, by then, a plan and associated costs will be available for review, so that we can discuss the plan and achieve consensus on conducting the work required at that meeting.

As stated above we will try to have one of our team attend the Forum in Malaga.

Erik