The Future of Portable Microscopes

IAHJ has run a series of articles from ioLight, reviewing how the portable microscope revolution increases productivity in farming and aquaculture and how the technology is impacting the developing world. In this final article, we look forward to what might be possible in the future.

Diagnostic Assistance

We have seen how the latest generation of pocket-sized high-resolution microscopes is already enabling vets and aquaculture specialists around the world to diagnose and treat disease immediately, even in remote locations. As well as cutting the cost of multiple farm visits and lab analysis, these technologies increase food productivity by treating unproductive stock fast. The microscopes store 1 micron resolution images and videos on a mobile phone. If internet access is available, vets, nurses and technicians can instantly share images for an expert second opinion and treatment plan.

But what if the second opinion was built into the microscope?

The combination of a mobile phone and cloud computing is powerful and raises the exciting potential of automatically matching an image captured in the field to a library of carefully identified images stored in the cloud. Clearly, there are practical difficulties as this would require a large library of images to be carefully labelled by experts. Nevertheless, using image recognition to assist a technician or nurse in common diagnoses or faecal worm egg counts anywhere in the world would hugely extend the reach of basic animal health. Reducing the mortality rate of working animals in the most remote locations, that currently have little or no access to animal health laboratories, it would also have a profound effect on poverty.

Having an easily accessible 'second opinion' would be a game-changer, particularly in developing countries. New technology like portable high-resolution microscopes will help in moving us one step closer to rapid disease diagnosis without the requirement for a highly trained on-site expert.

The National Center for Biotechnology Information has recognised the importance of rapid diagnostic methods through technological advances:

Disease surveillance and detection relies heavily on the astute individual: the clinician, veterinarian, plant pathologist, farmer, livestock manager, or agricultural extension agent who notices something unusual, atypical, or suspicious and brings this discovery in a timely way to the attention of an appropriate representative of human public health, veterinary medicine, or agriculture.

Most developed countries have the facilities to detect and diagnose human, animal, and plant diseases and have some type of active or passive surveillance for many well-characterised agents. However, many developing countries – where most of the global population resides – lack the resources or infrastructure to support such activities.

Nellie and Henrietta evaluating a portable digital microscope

One way to close this gap in infectious disease surveillance and detection may lie with the dispersion of technological advances such as regional syndromic surveillance, bioinformatics, and rapid diagnostic methods.[1]

Image recognition is already widely available to identify faces and places with alarming accuracy. A team from Cambridge University ran a short project in 2017 using mathematical methods to count eggs of gastro-intestinal nematodes in faecal samples from horses[2]. In just a few weeks the team was able to count eggs automatically with an accuracy of about 80% and there is great potential to improve on this. Google® uses artificial intelligence in its Vision AI® products that let image owners train the platform to recognise pictures from a library of images. This AI-led technology has the potential to match images from a portable microscope to specific pathologies in a library and diagnose common pathologies.

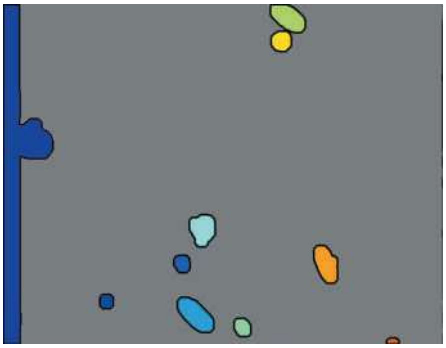
Challenges to Implementation

Artificial intelligence technology has evolved so quickly that it is unlikely to be the image processing that holds back these innovations. The biggest barrier will be access to case studies and the images required to build and label large libraries of reference images for specific pathologies. Once case studies are available with staff on the ground to sort and label them, it should be possible to make good progress.

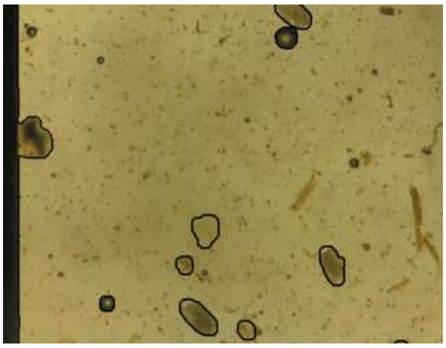
The second challenge is the development of a simple kit to collect samples and present them to the microscope without cross-contamination. Simplicity is the key here to ensure that these new tests can be delivered safely, reliably and cost-effectively by technicians with only basic training. Custom-designed collection kits are essential to the success of this endeavour, though the challenge is made easier as the microscope is inherently a non-contact instrument. Portable microscopes deliver images similar to those from laboratory microscopes, so the kits can also be similar. They will, however, require some adaption for use on the farm rather than in a laboratory.

Examples of image processing, courtesy of Cambridge University

This image shows a faecal worm egg count in a McMaster Chamber. The image contains several features that may be worm eggs. The contrast has been increased to give a black and white image identifying all the items of interest.



Each item can now be classified according to opacity, length width, shape and so on allowing each item to be categorised and coded.



The classification data overlaid on the original image showing the items of interest, ready for a veterinary expert to identify which classes correspond to worm eggs. The process becomes more effective with larger data sets.

The next step is to design a simple user interface that operates on a wide range of mobile devices. Many people in remote areas are very familiar with mobile phones and there are often good mobile data networks. This makes it an achievable objective, provided the user interface is not over-dependent on language.

Once the image libraries, sample preparation and user interface are in place, there is real potential to provide diagnostic assistance for a growing number of animal diseases. It is easy to see how such a service could be extended to human pathologies as well as animals.

A 2017 WHO report states that "800 million people spend at least 10 per cent of their household budgets on health expenses for themselves, a sick child or other family member". It continues, "For almost 100 million people these expenses are high enough to push them into extreme poverty, forcing them to survive on just $1.90 or less a day."[3] The WHO and the World Bank are working hard with NGOs to reduce health poverty, with some encouraging results. A cost-effective microscope that can assist diagnosis anywhere will be an important weapon in this battle.

The Potential

The work of building cloud-based diagnostic image libraries is significant, but the reward is potentially large. Once a library is useable, the owner of the library could offer access on a subscription basis. With such a large demand, we can expect that a relatively small subscription could generate significant revenues, further accelerating the development of new libraries of pathogens.

Perhaps the idea of a veterinarian or doctor in the cloud, that can instantly diagnose any condition and recommend a course of treatment, is a long way off, but the potential is there. Expert opinion and local knowledge are essential to diagnosis, but providing real-time diagnostic assistance to clinicians will greatly increase the reach of healthcare. Just as importantly, these technologies are inherently inexpensive and could be made available without creating further poverty.

Portable microscopes can improve the health of families and working animals

Furthermore, the generation of a big database of diagnostic images collected from animals and people from all countries and all social and economic backgrounds and over long periods of time has really exciting potential in epidemiology. It would enable researchers to mine the data for correlations and trends that would not be visible at a local or regional level.

Realising this idea will take collaboration between clinicians, research groups, big data companies and microscope manufacturers. It will be exciting to see how quickly digital diagnosis can be extended into areas of extreme poverty.

REFERENCES

1. https://www.ncbi.nlm.nih.gov/books/NBK52862/
2. Margaret Duff *et al*. 2017
3. https://www.who.int/news-room/detail/13-12-2017-world-bank-and-who-half-the-world-lacks-access-to-essential-health-services-100-million-still-pushed-into-extreme-poverty-because-of-health-expenses

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Andrew Monk is passionate about getting scientific innovation to the forefront of animal health and into the veterinary community. With Richard Williams, he is a co-founder of ioLight Limited. Together, they realised that there was an opportunity for a high-quality portable microscope using the latest developments in smartphone technology. Previously, Andrew was CEO of semiconductor fab Innos Limited and Président of GLOphotonics SAS. He has a masters degree in physics from the University of Oxford.

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