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Low-Cost Automatic Visual Inspection System for Hard Disk Drive Media in Mass Production

Final Year Thesis Project, 2012

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***Abstract*— Manual visual inspection is commonly adopted in modern hard disk assembly process to protect and speed up HDD inspection. A feasible automatic visual inspection system based on wavelength dependent detection has demonstrated good performance for defect detection on HDD media.**

Background

The world's *Hard Disk Drive* (HDD) market in 2010 was worth USD $27 Billion. It is expected to grow to USD $32.1 Billion by 2015 [1].

At the same time the steadily increasing commodity and labor costs causes reduce in profit margins [2][3], encouraging manufacturers to minimize waste and reduce costs. Faulty drives are disassembled, inspected, and usable parts are recyc

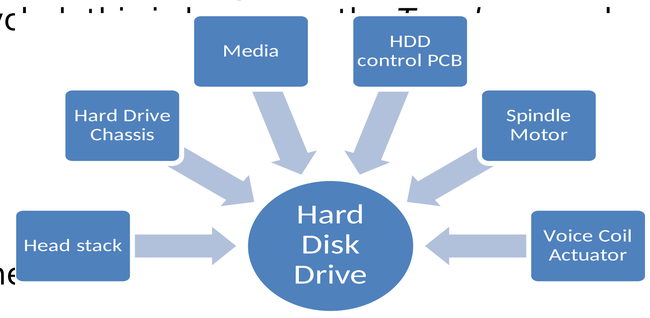

Figure 1: Illustration of Key Compone HDD

Of key interest is the HDD media. It is one of the most expensive components in the HDD, and as such is given emphasis during the *Teardown* process.

CURRENT PROCESS

HDD media quality testing includes the optical glide test using *Laser Doppler Vibrometry* (LDV) for surface testing and parametric tests for tests of magnetic properties. The LDV is capable of detecting faults of 1µm size on a hard magnetic disk , but has a relatively long test time of 50 seconds per HDD media and can potentially be damaged by surface defects. To alleviate this problem, HDD media is initially inspected by human operators in a process called *Visual Media Inspection*.

Targeted Defects

1. *Scratch* – fault in mechanical handling, error in manual (human) handling;
2. *Head crash* - fault in head stack assembly causing it to rest on the media surface;
3. *Ding* – fault in head stack assembly, causing it to bump against the media surface;
4. *Glovemark* – Glove contact with the media surface due to error in manual handling;
5. *Particle contamination* – excessive dust or particles on the media surface.

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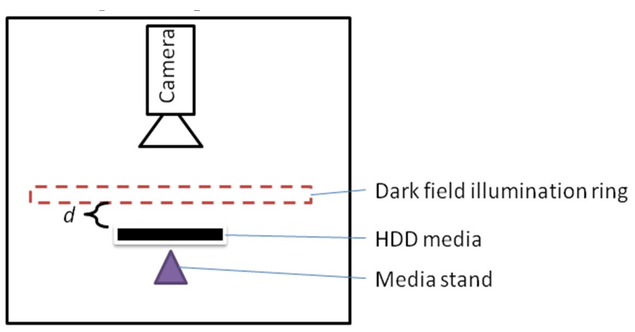

Figure 2 : Diagram of VMI Prototype

- The system is based around a Nikon D90 camera.
- Lighting is provided by VAOL-5GWY4 high intensity white LEDs placed in a ve a spectral output of 400nm – .

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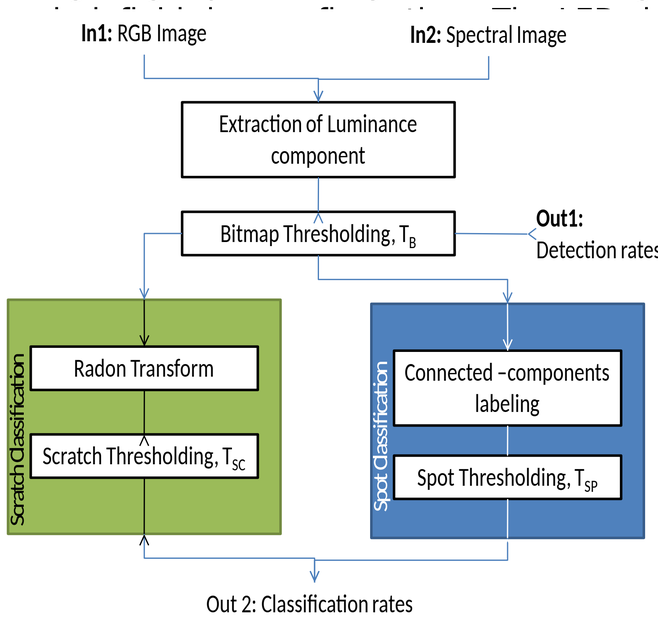


Figure 3 : Flow chart of Defect

Experimental Results

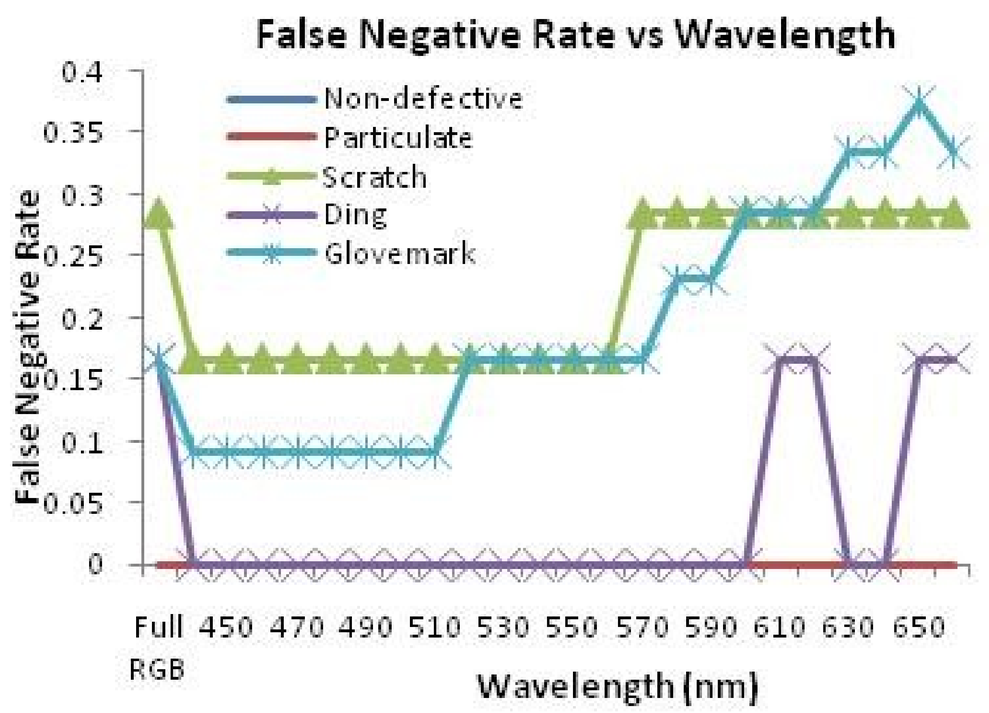
Large scale experiments were performed in Western Digital Malaysia in the Teardown stage, under Class-100 Clean Room environment.

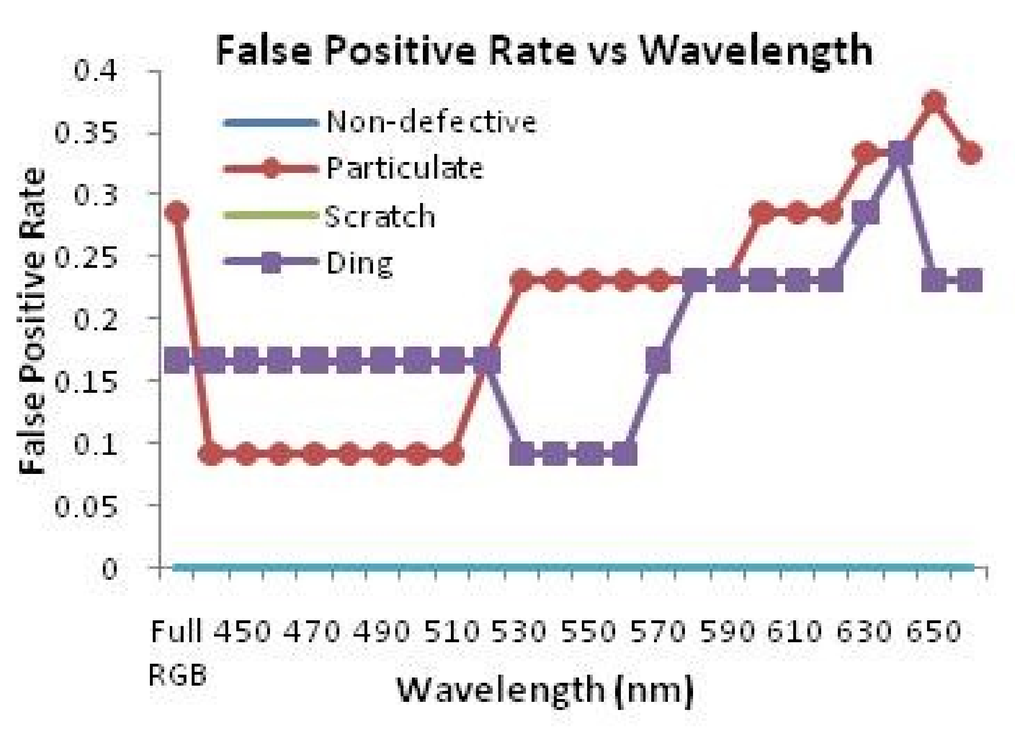
Defect Detection

The system could positively identify defective from non-defective media with 100% accuracy, regardless of spectrum.

Spectrum – Classification Dependency

The results show that the defect-background contrast is wavelength dependent. The Full RGB images tend to return higher false positives for particulate, and higher false negatives for dings and scratches. The 450-510nm wavelengths are best at detecting particles, glovemarks and scratches (whereby the false positive and false negative rates have the best tradeoff) while 540-570nm wavelengths have the optimal tradeoff for detection of ding





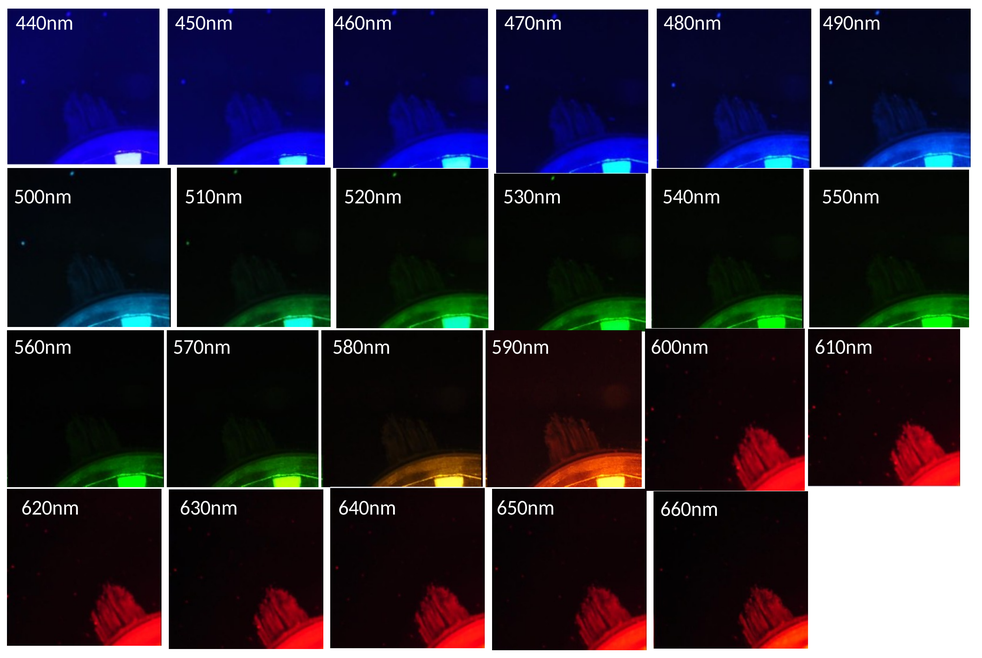


Figure 4, 5, 6 : Results of classification at various wavelengths.

Conclusion

A dark-field visual inspection system has been designed to performed HDD media inspection in mass production setting. The influences of major design parameters such as wavelength distribution of light sources, illumination distance and exposure time on the defect detection rate and classification rate has been studied. 100% defect detection rate can be achieved with a simple, hence fast, image processing technique. The use of wavelength specific imaging system will improve the classification rate.