A Portable Core Imaging Scanner

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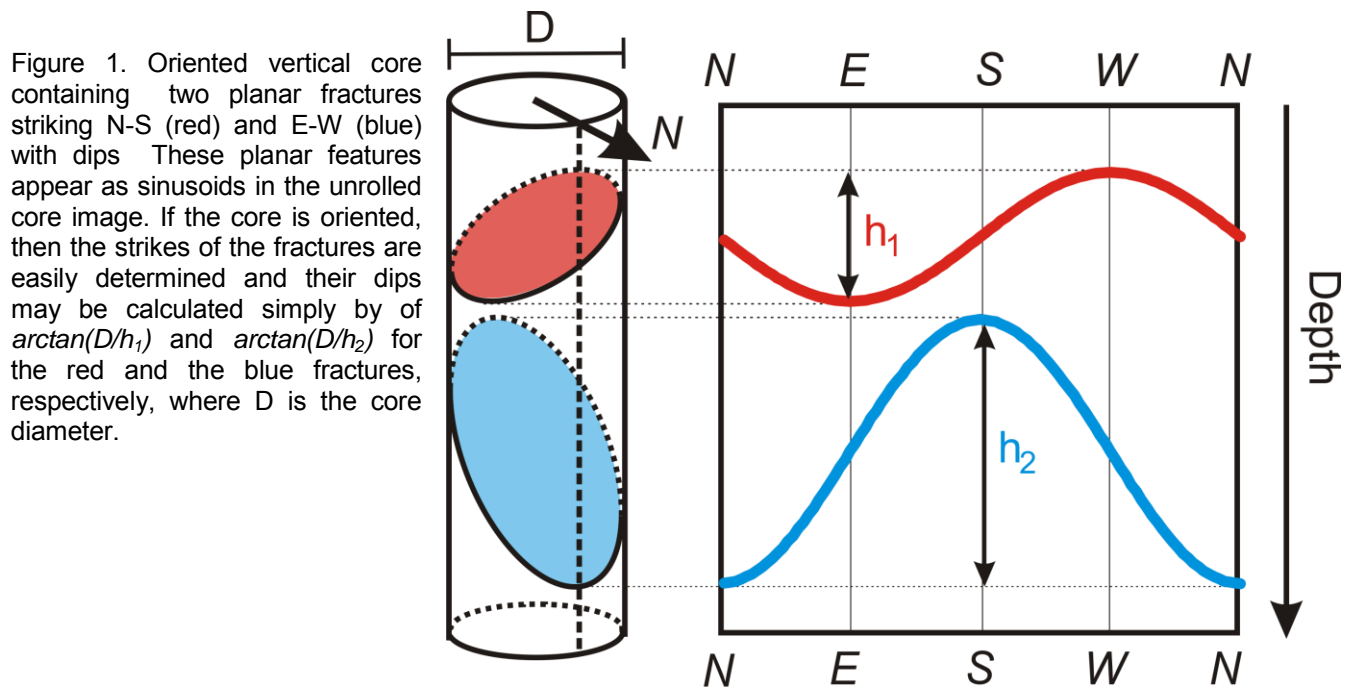
Summary

To aid with research involving drill core samples a relatively inexpensive and versatile portable visible light core scanner is being developed to work in both field and laboratory conditions.

Introduction

The growth of unconventional resources has placed greater emphasis on an understanding of in situ stress states and the characterization of fracture networks in the reservoir. Stress states can be constrained from the types of drilling induced fractures seen (Li and Schmitt, 1998). The existence of open natural fractures in the core, too, can provide additional limits to the stresses at depth (e.g., Moeck et al, 2009). Critical information from these fractures includes their strike (from oriented core) and dip. Such information is difficult to extract from standard whole-round or slabbed-core photographs. Fracture dips and relative strikes are easily extracted information can be extracted from unwrapped images of full-round cores (Figure 1).   Further, cores can be oriented geographically by integrating optical core scans with borehole image logs obtained using, for example, a televiewer (Paulsen et al, 2002) or a microresistivity imager (Fontana et al, 2010). For these reasons, a number of suppliers have developed optical core scanners, these are used primarily for geotechnical and scientific drilling purposes, their use in petroleum studies have been minimal.

One reason that core imaging has not been more accepted in the petroleum industry is that the equipment used for core scanning is relatively bulky. While this is not necessarily a hindrance for field studies, use of such equipment at core repositories is usually not practical. Research sites may be both remote and rugged, potentially limiting the amount and types of equipment that can be brought out by investigators for data acquisition and analysis. These limitations can lead to missed opportunities as specific sites may not be accessible for future study. In light of this, field equipment is typically designed to be as portable and versatile as possible. For similar reasons, portability and smaller size is crucial should one wish to carry out core scanning at conventional core analysis tables.

Many of our projects involve drilling sites. At these sites, we are interested primarily in measuring the physical properties of the local rocks and the regional/local and anthropomorphically induced (e.g. in response to drilling) stresses they are exposed to. In addition to natural stress induced fractures, drilling-induced stresses often generate fractures that are visible on the surface of the core retrieved from the borehole. Imaging these surface features represents the primary objective of this project: the development of a portable visible light scanner for imaging the surface of drill core. The resultant images should allow for visualization and basic measurements to be taken of the stress-induced fractures at a later date, without access to the original core.

Figure 1. Oriented vertical core containing two planar fractures striking N-S (red) and E-W (blue) with dips These planar features appear as sinusoids in the unrolled core image. If the core is oriented, then the strikes of the fractures are easily determined and their dips may be calculated simply by of $arctan(D/h_1)$ and $arctan(D/h_2)$ for the red and the blue fractures, respectively, where D is the core diameter.

Method

As the scanner would be used in the field the design parameters require that it be light, easy to transport, simple to use and versatile. Ultimately, we aim to develop a relatively automated system which will allow us to easily image core of varying diameters using the scanner and a notebook computer.

Aluminum is used for most components due to its cost and strength to weight ratio. The base plates, back plate, T-slot rails and side-mount track roller guide are all made of aluminum (Figure 3). The remaining core components are either steel or stainless steel.

Motor control, and potentially camera control, will be managed using National Instruments'™ LabVIEW system design software. The drive roller is to be driven by a hysteresis synchronous DA, DB geared motor. The camera mount will be driven by a similar motor, though may be changed to a stepper motor depending on precision requirements.

At present, images will be acquired using a digital single lens reflex camera – a Canon 7D with a 16-35mm f2.8L lens. This was selected for image quality, durability and versatility as it can be removed from the scanner and used for other still/video imaging applications. Image manipulation is currently being setup using MatLAB. We are in the process of writing scripts to unfurl, crop and stitch the acquired images into a single image of the core's outer surface. In cases where less detail is required we will attempt to generate surface images from video obtained using the camera, if this proves to be a faster method. Image processing and automation represent the most difficult aspects of this project.
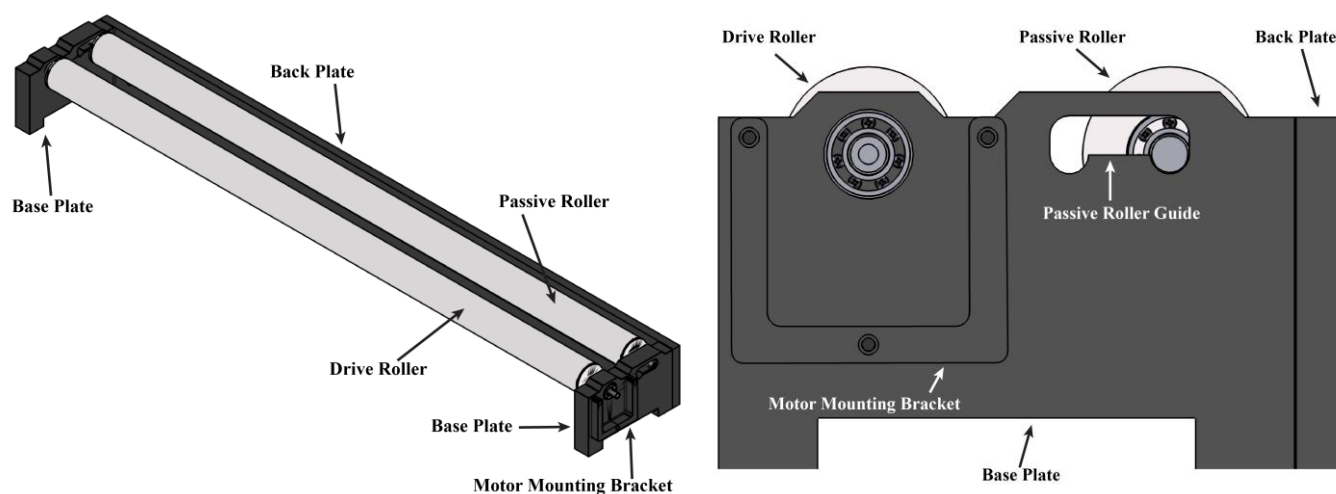
Figure 3: CAD generated images of the scanner assembly base without camera, motors or camera drive mechanism (Oblique View – Left, Drive Side View – Right). The rollers are 36 inches long having an outer diameter of 1.75 inches. The passive roller guide allows the roller spacing to be reduced for smaller core diameters. The rollers will be coated with a solid color not common in core to improve edge detection in the analysis software.

Examples

As construction of the unit has not been completed examples are limited to test images taken using the tripod mounted camera and Adobe® Photoshop®. The results of an application of the software's photomerge function provide a basic sample of primary objectives of this project (Figure 4). As mentioned above, MatLAB will provide more control over image manipulation and, once optimized, will work with low-contrast samples (e.g. sandstones, mudstones etc.) which present significant challenges to 'off the shelf' image stitching programs.

Figure 4: Single image of a piece of core containing incipient stress-induced petal fractures (Left) and the resultant stitched image of the entire core fragment (Right).

Conclusions

Once completed, this core scanner will be a valuable tool in both laboratory and field environments. In the future, the scanner may be modified to perform imaging outside the visible spectrum.

Acknowledgements

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