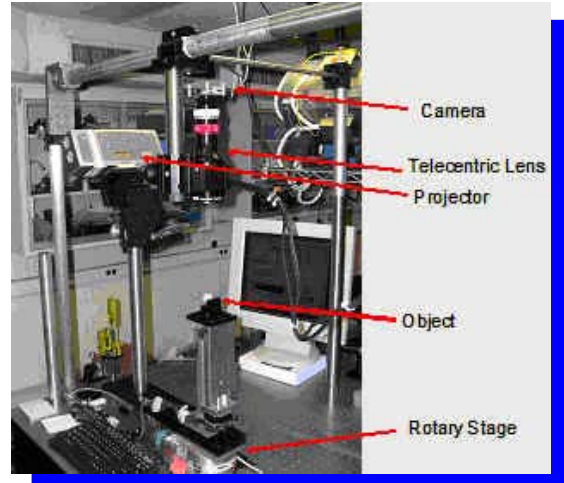


# Three Dimensional Scanning System

## Market Need

Protecting and preserving valuable objects such as jewelry, art, coins and artifacts is complex and evolving. Historically, security and defense of the physical location of treasures was vital. Ancient tombs and temples were solidly constructed to be impenetrable and long lasting. Over time, more flexible technologies developed that provided safekeeping as well as access. With increased access to property, light, humidity, handling and other environmental factors began to negatively affect smaller, fragile pieces. Today, security systems continue to rely on impenetrable materials and solid construction but also employ cutting edge technology that balances security, accessibility and preservation. Museums and universities demonstrate this balance by housing large, valuable and varied collections for protection, characterization and study; artistic, historic, biologic, archeological, geologic, etc. Government crime and justice agencies must also balance custody duties with public access while ensuring the physical integrity of important evidence and forensic objects.

A technology that reduces the need to repeatedly remove an item from safekeeping, handle and expose it to harsh environments; yet allows unlimited opportunities to view and study an item's unique and potentially elaborate physical characteristics, would play an important role in preservation, academic, judicial, insurance and security markets. While different technologies have been investigated to digitally capture details of an object, only the **Three Dimensional Scanning System**, developed by researchers at The Johns Hopkins University Applied Physics Laboratory, constructs accurate, detailed surface maps of small objects.



## Features

Originally developed to address specific issues presented by cuneiform tablets, the resulting **Three Dimensional Scanning System** acquires the shape, color and reflectance of items and compiles these characteristics into complete 3D objects.

The system translates scanned objects into digital data that is capable of being saved, copied, shared and manipulated with suitable rendering software. With the resulting image, users could have unlimited access to the most rare, fragile, expensive and protected objects. They would be able to specify any view direction and lighting condition to best analyze and appreciate the object.

Specifically, the scanner uses a camera and telecentric lens to acquire images of an object under varying controlled illumination conditions. The scanner processes image data using photometric stereo and structured light

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techniques to determine the shape; then color information is reconstructed from primary color monochrome image data. The scanned surface is sampled at 26.8  $\mu\text{m}$  lateral spacing while the height information is calculated on a much smaller scale. Finally, software stitches together the scans of adjacent sides of an object to form a 3D surface model.

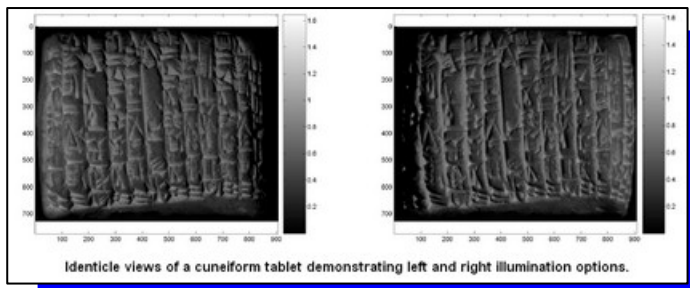
In developing the scanner, APL researchers uniquely combined photometric stereo analysis (psa) data and structured light analysis (sla) data to determine the true and detailed shape of an object. This is a remarkable discovery since there are shortcomings associated with each data set. Normal data from psa is accurate locally, but does not form a consistent surface and cannot be integrated to obtain a globally accurate object shape. Height data from sla, on the other hand, is accurate globally but noisy and inaccurate on small, local scales.

Other scanning technologies fail to match the **Three Dimensional Scanning System's** combination of attributes. Laser scanners can not deliver high-resolution images. Scanning electron microscopes, while higher in resolution, operate slowly and make a lot of noise. They also do not provide color information.

## Technology Status

The invention is a working prototype and supported the National Science Foundation's Digital Hammurabi Project for which it remarkably determined the surface shape and details of cuneiform tablets. The scanner acquired data at 26.8  $\mu\text{m}$  x- and y-sample intervals over an area of approximately 34.3 mm by 27.4 mm. The resulting final surface is both globally accurate in accordance with height information as measured by a structured light technique, and locally accurate in accordance with slope information obtained by the method of photometric stereo.

The scanner uses off-the-shelf hardware components, minimizing the system cost and allowing for easy expansion and scalability.



Identicle views of a cuneiform tablet demonstrating left and right illumination options.

Customized visualization software delivers examination capabilities that far surpass photographic records. In addition, the software provides features to enhance details beyond those seen through direct inspection of the actual object.

### Software features include:

- Adjustable light source
- Depth-based surface shading
- Adjustable surface reflectance
- Variable view direction
- Adjustable magnification

## Commercial Benefits

The benefits of digital documentation further enhance the key features of the **Three Dimensional Scanning System**. This technology will positively impact markets requiring accurate, detailed, indelible and versatile representations of three dimensional items; whether for:

- positive identification of possessions by adjustors for property insurance or proof of ownership,
- world-wide distribution of rare and distant objects by researchers for enhanced educational opportunities and collaborative research,
- analysis of objects from crime scenes by distant specialists for consideration in judicial proceedings, or
- manufactured replicates of artifacts and treasures by museums, galleries and stores for display and sale.

## Intellectual Property

US Patent Pending, 11/465,165

## Availability

Currently seeking a qualified commercialization partner.

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