Solid Modeling With Unlimited Real-World 3D Data on a Cell Phone

Introducing Voxal Group's Verocloud

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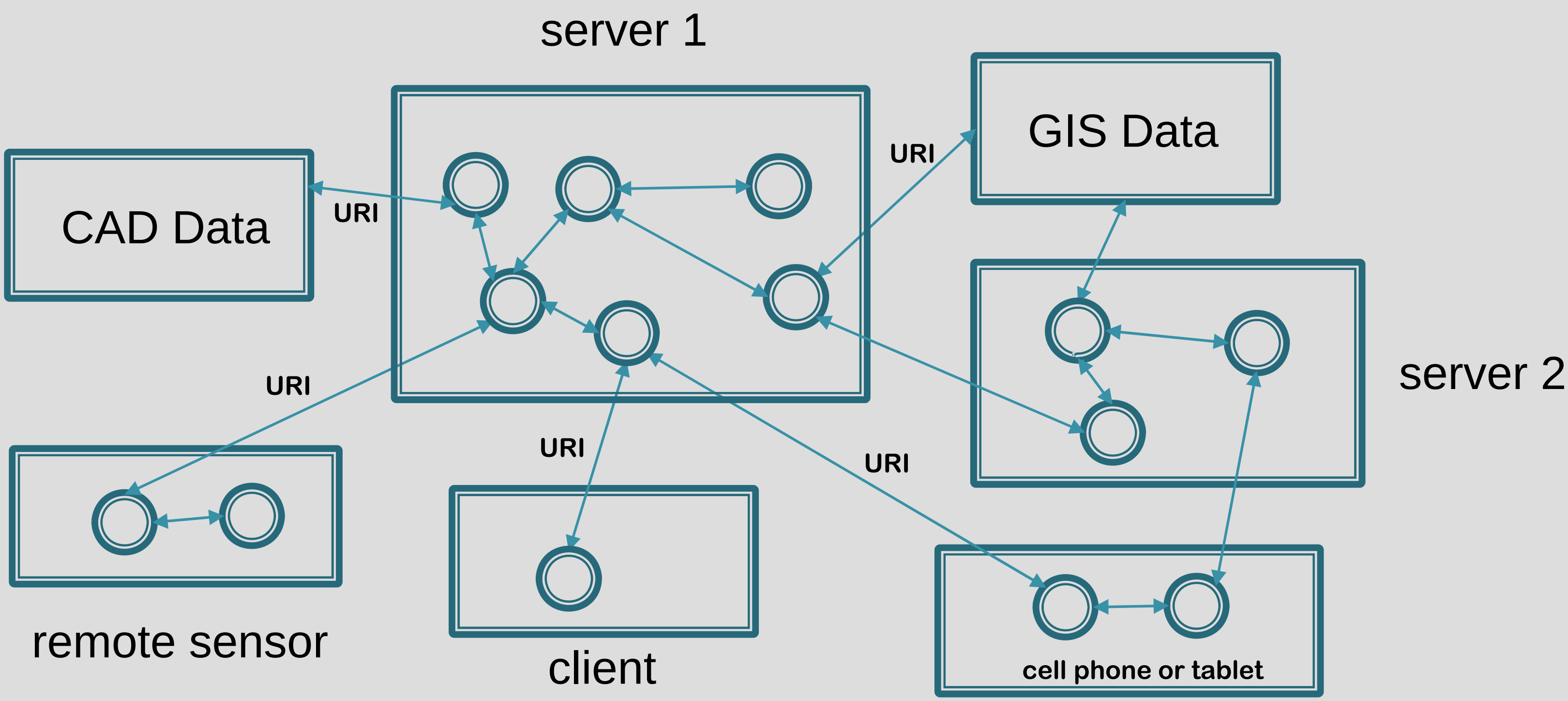
Dr. Donald J. Meagher
Marek Sekowski

Introducing Voxal Group's Verocloud™

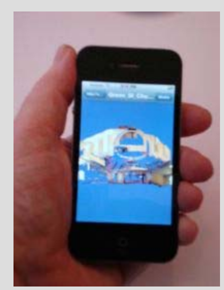


Distributed Virtual PowerGraph™

RDF node with URI pointers to PowerGraph resources

Verocloud wireless client

Android (Motorola Xoom)



Apple iOS (iPhone 4)

"A Solid Modeling Engine in Your Pocket"

Real-World Data

Yesterday: Welcome to the World of BIG DATA.
Today: The Data Deluge is Coming!

Real-world data is growing <u>much</u> faster than computing power.

Defense Department

- Now collecting ISR (Intelligence, Surveillance, Reconnaissance) data (increasingly 3D/4D) at 1peta-byte (1PB) per day (1PB = 1000TB = 10^{15} bytes).
- Projected to reach 1 yotta-byte (1YB) per year in 2015 (1YB = billion PB = 10^{24}B; estimated output of sun: 383Y watts; estimated diameter of universe: 880Y meters).
- Estimate to store 1YB in 2015: $3.2 trillion.

Mega	10^6
Giga	10^9
Tera	10^{12}
Peta	10^{15}
Exa	10^{18}
Zetta	10^{21}
Yotta	10^{24}

International System Of Units (SI)

Medical Scans

Yesterday: 100 slices 512x512 or ~50MB/study
Today: 24,000 slices 512x512 or ~20GB/study
Soon: 5 sec. x 100 Hz x 1024 x 1024 x 1024 or ~1TB/study

Research

The “Connectome” (map of brain’s circuitry) est.: 1 zetta-byte (1ZB)

Where is All This Data Coming From?

The Life Stages of a Sensor

1. Great idea! (To sense some real-world phenomenon.) Result: It works! ("Wow. It's amazing what technology can do!")
2. Field test. Promising, but needs improved … (gain, speed, bandwidth, resolution, cost, etc.). Result: Continuous improvement.
3. Wow, there's lots of data. (Especially true with additional dimensions.) What do we want to do with it? Just view it! Result: That's hard (but not very hard).
4. I see it but what I really want to do is ____! (Exploitation .) Result: That's REALLY hard. Progress is slow. ("Wow. It's amazing what technology CAN'T do!")
5. Now we need to capture real-time activity. Soon we need to run it continuously (e.g., what we seek is transient or hiding or both). Result: Persistent surveillance.
6. There's too much data for human consumption (or to save). Result: Characterize it in real-time, build models on-the-fly, discard redundant & uninteresting data (which is almost all of it) immediately. And do this at the sensor.
7. For best exploitation, needs to play well with others (other sensors). In real time. Result: Sensor fusion? Connect the dots?
8. We can now take advantage of a wide variety of diverse sensors (type, cost, sensitivity, etc.) that are geographically separated. Result: Communications bottlenecks. Sensor cueing. Layered sensing.
9. ???

Major Challenges

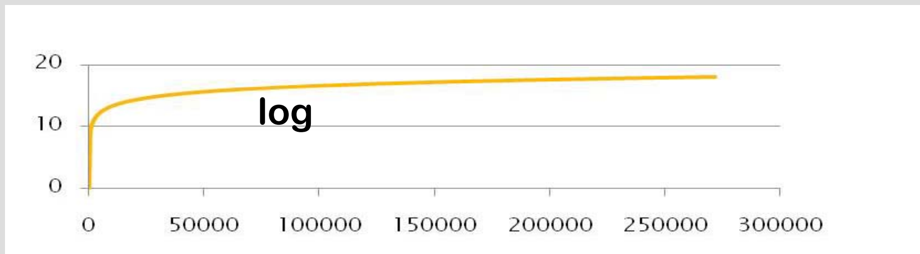
- SIZE: Huge datasets.
- TYPES: Disparate data types (scan, CAD, animation, medical, GIS, etc.).
- COMPUTATIONS:
  - Linear growth bad (e.g., display using 3.5B transistor chips for toy worlds, latest Shrek movie rendering took 50,000,000 CPU hours).
  - Advanced exploitation much worse (e.g., "Have I seen ___ this before?").
- NETWORK OPERATION: Effective use over networks needed.
- RELIABILITY: Algorithms can fail.
- PLATFORMS:
  - Major challenge for powerful multi-core desktops with specialized graphics hardware.
  - Now moving to wireless portable devices (e.g., phones & tablets).
  - With spatial data the answer is not with increasing computer power but reducing computational and bandwidth requirements.

Is There Hope?

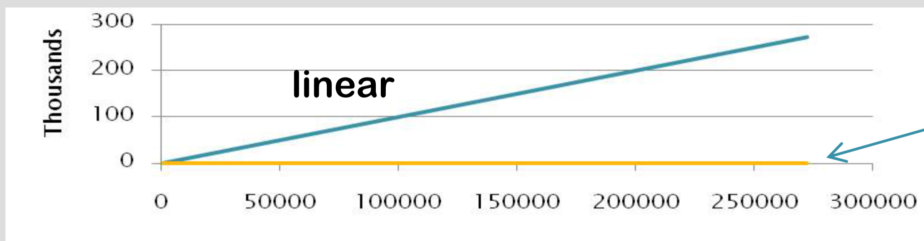
- **Basically unlimited data handled and exploited in other areas.**
  <u>Example:</u>
  - **Catalina Marketing: 2.5PB database (1,000,000GB) of consumer transactions (e.g., 1 table with 600B rows) handled & exploited.**
  - **Use: your custom coupons at the supermarket!**

<u>linear vs. log growth</u>

logarithmic growth



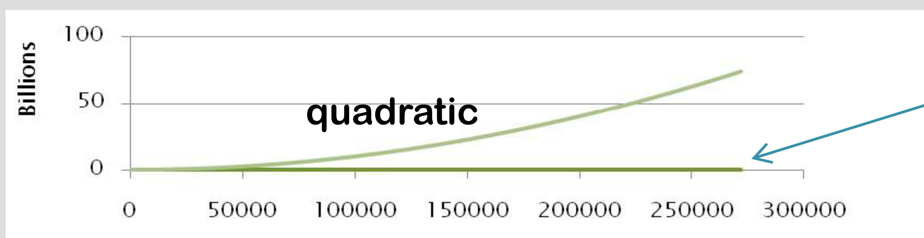
linear growth



log

<u>BUT exploitation can exhibit much worse growth</u>

quadratic growth



log & linear

Transforms

A "transform" is a mathematical method of converting information from one "domain" into another where important operations are easier to implement, operate faster, and so on.

Fast algorithms are the key to success.
For example: Fourier Transform vs. the FFT (Fast Fourier Transform).

- Compute π to a billion digits with FFT ($O(n \log n)$ algorithm): < 1 hour.
- Using $O(n^2)$ Fourier algorithm before FFT: about 10,000 years.

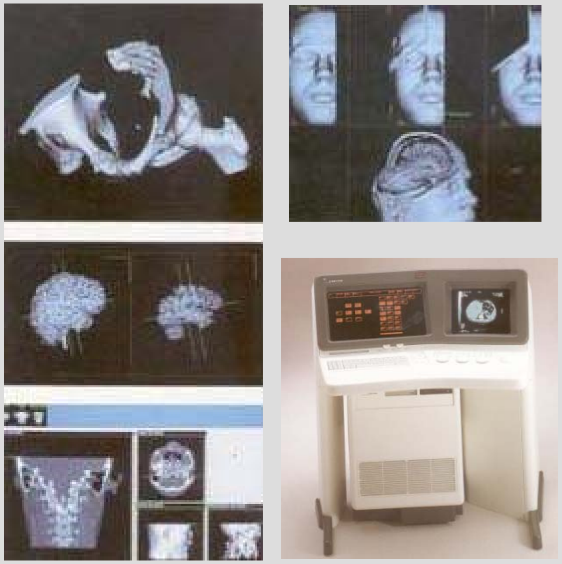
In order to drastically reduce the computational cost of handling and exploiting large amounts of spatial data the "Octree Transform" was derived. Information is transformed into the "Octree Domain" for processing.

The Octree Transform

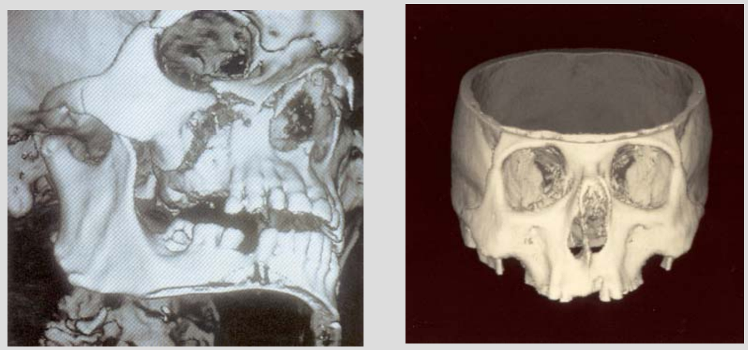
Characteristics of information in the Octree Domain

- SIZE: Data set size is essentially unlimited.
- TYPES: Just about any type of spatial information from points to time-varying solids can be readily converted into and represented in a common format.
- COMPUTATIONS: The computational complexity growth characteristics of key algorithms are greatly improved. (Display O(log n), exploitation usually O(log n) to O(n log n)).
- NETWORK USE: Operations can be effectively performed over limited-bandwidth channels.
- RELIABILITY: Unreliable methods generally not needed.
- PLATFORMS: Effective operation even on wireless devices.

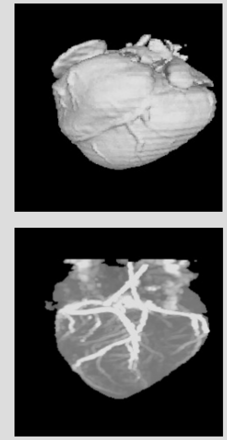
Use of Octree Transform



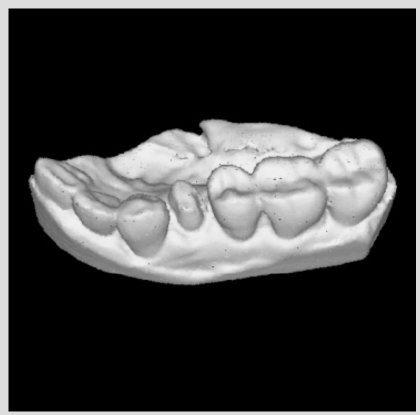
GE CT Highlight Advantage Console



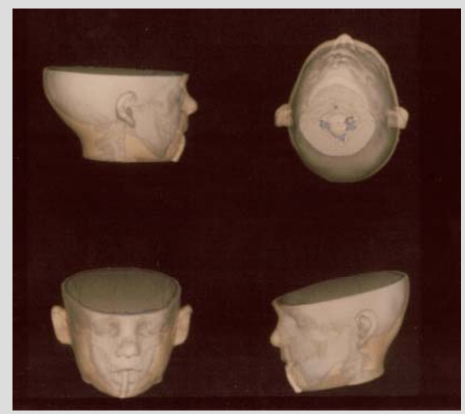
Craniomaxillofacial surgery



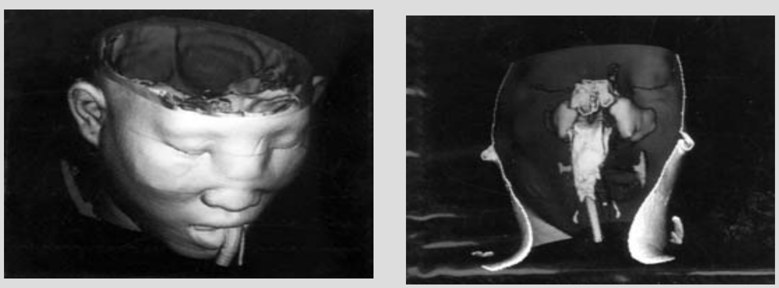
Heart studies



Dental

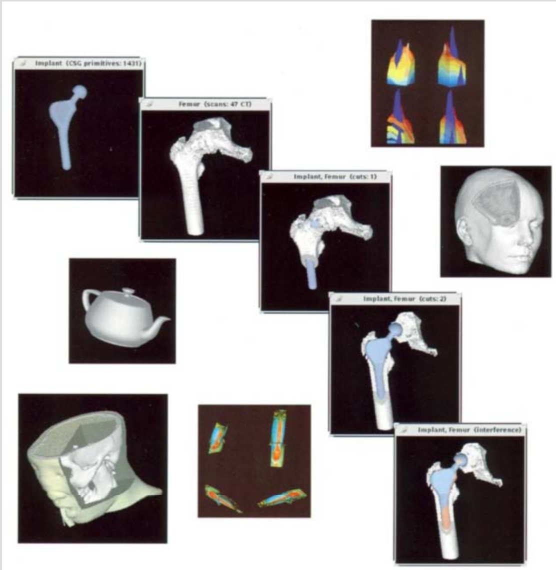


Treatment planning



Surgical simulation

Additional Uses

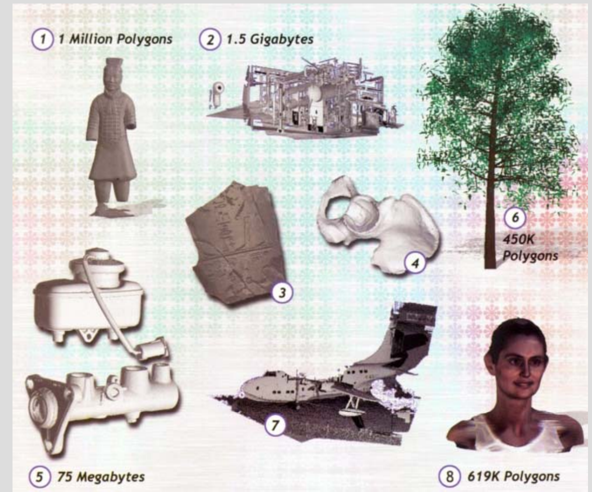


Use in medicine (implant design, surgical planning, etc.), geological, industrial and other areas

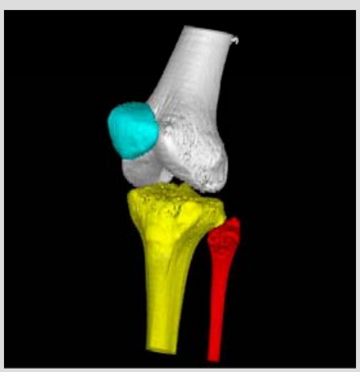
NaviPro™

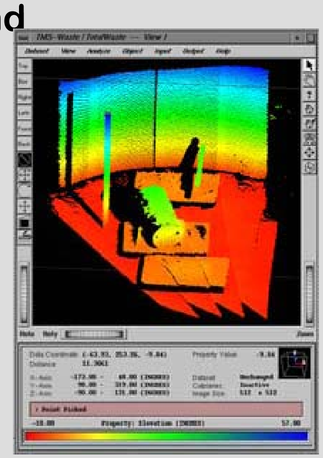
Surgical Procedure for THA
Version 1.0

Surgical navigation system

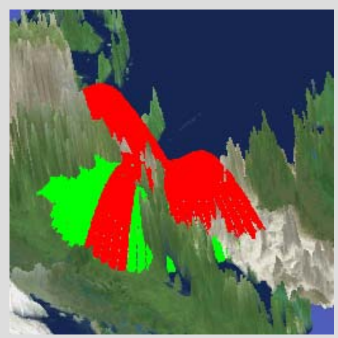


datasets





Interactive Computer Enhanced Remote Visualization System (ICERVS) for DoE nuclear cleanup

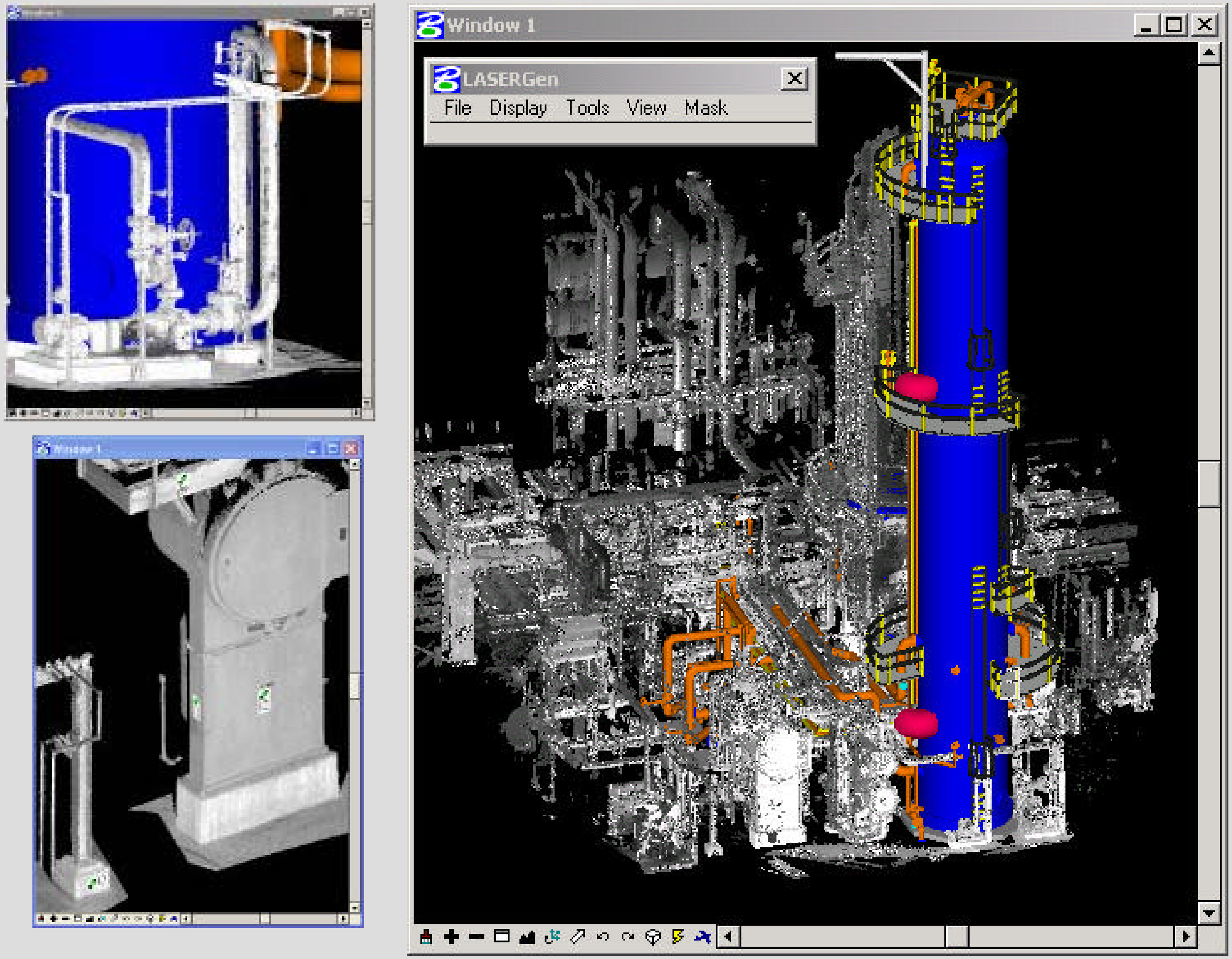


Interactive Artillery Shadow System

Segue II board for real-time 3D LIDAR shape matching & 3D/4D model building

Industrial Laser Scanning

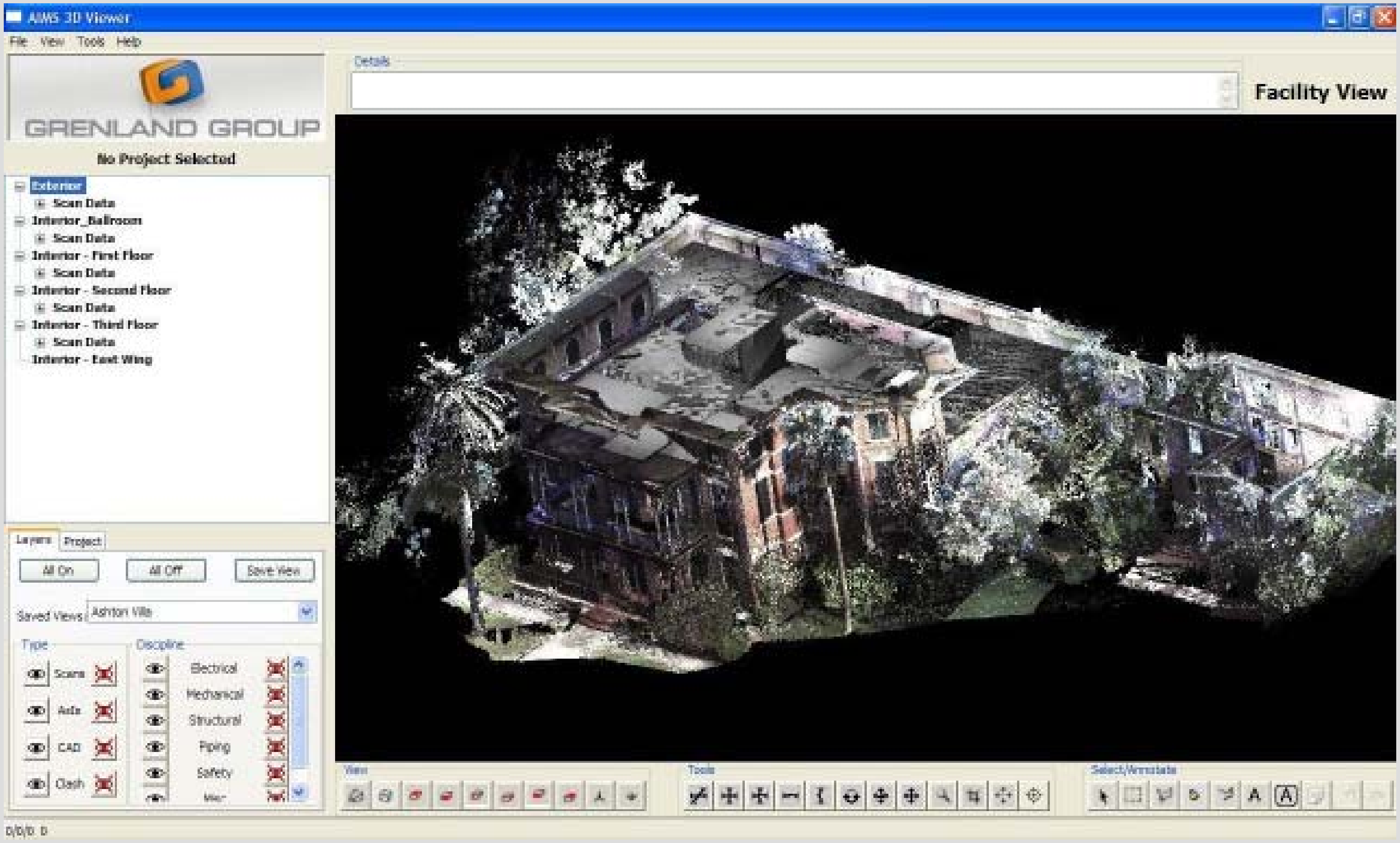
(Geometric/Sampled Set Ops)



BitWyse LASERGen

Industrial Laser Scanning

Use Over Internet



Grenland AIMS