ArcGIS 3D Analyst: 3D Analysis

Brady Hoak and Gore Bolton
ArcGIS 3D helps customers to…

Create and Manage

Quickly and easily extract value from 2D and 3D data

Design and Simulate

Manage the designed environment

Visualize and Analyze

Understand and experience events and change
Support 3D GIS across industries

Scientific Visualization

Mining

Developing Energy resources

Utilities and Telecommunications

Environmental assessment

Transportation

Utilities and Telecommunications

Facilities Management

Land Information Management

Military
Complete workflow for editing, managing, publishing and sharing data in 3D
Key Places within the Platform for 3D Analysis

- **ArcGIS for Desktop** (ArcScene, ArcGlobe, ArcMap, ArcGIS Pro)
  - Includes 3D Toolbars and 3D Geoprocessing Tools

- **ArcGIS for Server**
  - 3D Published Geoprocessing Services (that use a 3D tool)

- **CityEngine**
  - CGA rule (that transforms a 3D aspect of a building)

3D Analysis is a workflow to solve a 3D problem.
Analysis Capabilities of 3D Analyst

**Area & Volume**
- Detect Change
- Determine Cut/Fill
- Calculate Surface Area & Volume

**Overlay**
- 3D Statistics
- 3D Proximity
- 3D Intersections
- Visualization
- Profile Graphs
- Interpolate Features
- Extrude Between Surfaces

**Visibility**
- Line of Sight
- Viewshed
- Skyline
- Shadow Modeling

**Data Management**
- Data Creation
- Data Conversion
- Lidar QA/QC
- Lidar Classification
- Surface Interpolation

**Surface Derivatives**
- Contours
- Slope
- Aspect
- Hillshade
- Statistics
- Identify Outliers
- Interpolate Geometry
- Perform Math Operations
Examples of 3D Feature Analysis

- Visibility Analysis
- 3D Volumetric Modeling
- Shadow Analysis
Complex 3D Features

The answer is multipatch!
3D Features Toolset

- **Overlay**
  - Intersect 3D
  - Union 3D

- **Proximity**
  - Buffer 3D
  - Near 3D
3D Feature
Intersect

Intersect 3D Tool

Intersect two multipatches to create a new multipatch.
Viewshed Tool in ArcGIS Online

1. Visibility settings (optional)
   - Height of Map Notes Points: 50 Feet
   - Height of other objects on the ground: 0 Feet
   - Maximum viewing distance: 10 Miles
Visibility Toolset in Desktop

- Line of Sight
- Construct Sight Lines
- Intervisibility
- Viewshed
- Sun Shadow Volume
Line of Sight Examples

- Viewshed
- Line of Sight with Obstructions and distance limits
- Cumulative line of sight
- Line of sight to a polygon or line
- View assessments between objects
- Visual Prominence of a single feature
CityEngine Exports to the Geodatabase for Analysis
ArcScene Analysis with CityEngine Buildings – Visual Connectivity
McCarran Airport Tower/Apron LOS Analysis (3D Web Scene)

Description

ArcScene was used to perform a line of sight analysis using 3D vector (esri multipatch) data and elevation data to a grid of 5m spaced test points on the airport apron from the observation tower. The observer point was then raised 10m higher to create alternate results. One could use the interactive swipe tool to perform the comparison. Airport incursion points on the apron show the locations of two incursions. Ideally with further analysis incidents such as these might be prevented if they could be seen by controllers.

Las Vegas McCarran Airport Buildings from CyberCity 3D
How visible are these buildings to the surrounding area?

Cumulative line of sight analysis, with visual prominence / quality.
Cumulative Line of Sight
Cumulative Line of Sight
Cumulative Line of Sight
Cumulative Line of Sight
Cumulative Line of Sight
Cumulative Line of Sight
Cumulative Line of Sight
View Assessment
View Assessment
View Assessment
View Assessment
View Assessment
View Assessment
View Assessment
View Assessment
View Assessment
Improved Streets

View Assessment
View Assessment
View Assessment
Demo – Line of Sight Analysis – Camera Visibility to Route

- ArcGIS Pro
- Realistic Buildings
- Tree and Bldg Obstructions
- Cumulative Line of Sight
- Bidirectional
Demo – Cont.

- Construct Sight Line
- Line of Sight
- Iterate Model for each observer
- Multipatch Buildings obstruct

Perform Basic LOS (Obstruct with Terrain and Buildings)
• Use Intervisibility for Multipatch Trees
• Perform on only the visible targets
• Filter out the result
Skyline and Skyline Barrier

- Which buildings define our skyline? How high can we build without changing our skyline?

- Intersect sample points with a surface created using skyline barrier, then using it to generate a buildable volume.

The resulting intersection points can be converted into a TIN and extruded down to create a volume.
Shadows and Shadow Maps

- Where do shadows fall? How can we quantify their impact over time?

- Intersection of shadows, at specified time intervals, for specified days in the year, on a park polygon.
3D Routing

- Release of ArcGIS 10 provided support for 3D Transportation networks

- Building Interior Space Data Model (BISDM) v3.0 supports the development of the required data components
Creating Data – **Floor Lines**

- Hall centerlines
- Fillet
- Bezier curves
- Route to door
Creating Data – Floor Transitions

Floor 1 plan
Add z-values to vertices
Floor 2 plan
Add z-values to vertices
Floor 3 plan
Check in 3D
Elevators
Understanding the Surface
What is it & when should it be used?

Any continuous measurement with one value for a given x-y location $z = f(x,y)$

- Temperature
- Gravity
- Soil studies
- Epidemiology
- Chemical concentrations
- Many diverse applications...

More than just topography!
Surface Data Types

Raster Surface
- Made by interpolation, generalize source measurements to cell size
- Supports robust mathematical operations

TIN Based Surfaces
- Created by triangulation, maintain source measurements
- Support robust surface definitions & data
Triangulated Irregular Network (TIN) Based Surfaces

Overview of Data Types

**TIN**
Well-suited for engineering applications and analysis of study areas that are not exceedingly large, provides interactive editing options.

**Terrain**
Multi-resolution, scalable, offers robust support for handling large amounts of data.

**LAS Dataset**
Rapidly visualize, filter, perform QA/QC and analyze lidar data. Well suited for aerial collections, supports compressed lidar in ZLAS format.
Choosing the Most Appropriate Surface Model

- What is the nature of data being modeled?
- How is the data distributed?
- How will the data be used?
3D Scene Creation – James River Example
James River Project

- Decided on 65 mile study area extent
- Obtained lidar for entire area from source site
- Digitized water polygon to enforce breaklines and affect tree placement
- Processed lidar to create elevation
- Processed imagery and lidar to create tree points with height
- Created rotated towers with realistic model using CityEngine rule
- Digitized building footprints for power structure facility
- Hand modeled historic plantation building as collada ‘as-built’ models
- Created webscene in order to show reflective water
- Determined animated path to tell a story
- Created .mp4 video capture of story path
65 Square miles of LIDAR data used with NAIP imagery

Water breaklines added to LIDAR ground to create Terrain
DEM and Trees (Height, Placement) – Derived from Lidar
Position and Scale 3D Towers Using Lidar Elevation and Feature Attributes

Transform 2D Feature Service into 3D Objects with CityEngine

- Ground Elevation from LIDAR
- CityEngine 3D Rule
- Features From CityEngine Rules
- 3D Objects
- Extract Values to Points
- Feature To 3D By Attribute
- Buffer 3D
- towers2D
- workspace
- towers2
- towersZ
- towersZ_Buff3D

Create3DwithCityEngine_service
CityEngine
Tower Rule

```java
attr TYPE = ""
attr ROTATION = 0
attr SIZE = 0
attr MODEL_ASSET = "assets/towers/tower1.obj"

//attr MODEL_ASSET =
//  /// case TYPE == "Tower" :
//  /// case SPECIFIC == "Large" : "assets/towers/tower.txd"
//  /// case SPECIFIC == "Small" : "assets/towers/tower.txd"

# Rules

@StartRule
Point -->
alignScopeToAxes
z(0, SIZE*.38, 0) center(xz)
r(0, -ROTATION, 0)
i(MODEL_ASSET)
```
Water Breaklines Preserved in DEM Creation
CityEngine Rule Packages Create Simple Textured Buildings with Roofs
Hand Modeled ‘Signature’ Historic Buildings Imported as Collada Models
Demo – James River Webscene Video
Published Image Service From Lidar - DSM and DTM

- Rest Endpoints to Service
- Connect from ArcGIS Desktop too
DSM Service with Hillshade Applied on the Fly
DTM Service with Hillshade Applied on the Fly
Comparison of Elevation Profiles Using 3D Analyst Profile Tool

DSM Profile

DTM Profile
Using Lidar to Calculate Building Heights

- Create a ground surface from ground returns – DTM
- Use first return to create a DSM surface
- DSM – DTM = nDSM
- Use Zonal Statistics to find height over building footprints.
Obtain Digital Surface Terrain Model Raster (DSM) from Lidar – Here is the LIDAR data first return points LAS Dataset in ArcScene
Calculate Building Heights and Levels Above Ground from nDSM
Demo – Presenting Analysis In WebScenes

- Solar Potential
- Buildable Volume
- Shadow Patterns
Volumetric Analysis – Dredging Example
3D Community on ArcGIS Resource Center
http://resources.arcgis.com

- **Helpful Utilities**: LAS Optimizer, Custom Tools

- **Solution Templates**: Guides and sample data to illustrate best practice applications for tasks in 3D

- **News**: Learn about what’s new in 3D GIS.
3D views of power are powerful
How it helped Washington DC

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Currently Founder and CEO of www.landfaxusa.com
The analysis in Washington DC


- **What it was**
  - Simple analysis of several heights

- **What it was not**
  - A skyline development plan
The analysis of Washington DC

- Scope of work as requested by DCOP and Congress
  - Three fixed heights
  - View corridors of significance
  - Historical views

- The real challenge of two dimensional streetscapes
  - Photos photos photos
  - Not much latitude to “play” with scenarios
  - Having to overlay ages and possibility/probability of redevelopment

- How City Engine made the extrusions
  - Stepwise
  - Could have been leveraged even more (i.e. block by block, and reverse lines of site)
  - Construct of “height zones” based on places of significance (i.e. we don’t want the views on the mall to change)
- Gore Bolton – 3d City Planning
The District’s visual modeling study shows that even increasing building heights to 160’ under the ratio proposal begins to diminish the presence of the U.S. Capitol dome.
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