Research on Spatial Database Building Method Based on ArcGIS for AutoCAD

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Abstract. Dwg file was widely used as the output file format of the surveying and mapping project produces at present. With the project amount of surveying and mapping increasing, it is necessary to establish a spatial database to scientific and unified manage various surveying and mapping thematic data results. When creating the spatial data based on the dwg file, the graphic information in dwg is extracted, and the attribute information corresponding to the graphic needs to be supplemented at the same time. This paper proposes a method of building spatial data based on ArcGIS for AutoCAD plug-in. This method can realize the unified management of graphics and attributes in CAD environment. Spatial and attribute information contained in the dwg file can be extracted quickly and accurately base on secondary development with ArcEngine, and the application value of the dwg file in the field of surveying and mapping was improved greatly.

1. Introduction
As a popular vector drawing software, AutoCAD is simple in graphics operation, powerful in graphic editing, and provides a rich secondary development interface to support multiple development methods. Therefore, this software has been widely used in the fields of architecture, planning, design, mapping, geology, etc. [1]. The land, planning and other departments as well as corresponding enterprises and institutions have accumulated a lot of dwg formatted AutoCAD project outcome. From the current point of view, use dwg file as spatial data storage format will continue for a long time [2]. The advantage of GIS lies in data analysis and mining, which can be used in the field of spatial information collection, storage, modeling, query, display and output. Although the GIS software provides a strong graphical editing function, editing and modifying data in AutoCAD environment is more convenient and precise than the corresponding function provided by GIS software. Although the display effect is excellent in dwg file, it is impossible to establish a complete geographic coordinate system and projection transformation in dwg file, and the ability of managing the attribute information of the graphic and the spatial topological relationship is much more complicate, thus resulting in geospatial information stored in dwg file cannot be directly used in urban geographic information systems [3]. In order to make full use of these two softwares, and use dwg file as the basic data source of GIS, we must improve the manage ability by seamlessly converting dwg file into GIS-supported data [4]. This paper compares several kinds of methods of building spatial data based on CAD data, and proposes a rapid database building method based on ArcGIS for AutoCAD plug-in in AutoCAD environment.
2. Attribute Data Manage Method Base on DWG File

Currently, when using dwg file to build spatial data database, it is necessary to extract the graphical information and attribute information contained in dwg file. Since AutoCAD software has strong graphics editing ability, but weak attribute editing ability, in order to maintain corresponding attribute information of graphs and prepare for database building, the following three methods are usually adopted [5]:

2.1. Deal Graphic and Attribute Separately

The data produce department uses AutoCAD to complete the production of the project results graphic, then the data manage department converts the graphic into a format supported by the GIS database, and defines the attribute field corresponding to the graphic. Attribute information was attached to the graphic under ArcGIS environment interaction. This can affiliate the attribute information after graphic information into the database. This kind of processing method separates the graph and attribute of spatial data artificially, which easily leads to errors in graph and attribute information.

2.2. Attribute Database Affiliate to Graphic

In this way, a property database is hung in the graphics system to associate the graphics information of entities with the property information, so as to realize the real-time import of graphics and properties into the database. Due to the different emphasis on data requirements between data production units and data management application units, data production units are often reluctant to maintain the external attribute database, which makes it difficult to synchronize graph attribute information. In addition, this method requires separate development of attribute data maintenance module and deployment in terminal, which is not convenient to use.

2.3. Graphic with Extended Attribute Information

The extended attribute mode provided by dwg file can manage a large amount of attribute information of the graphics entity. This extended attribute is closely combined with the graphic entity, which is conducive to the integrated operation and the logical consistency of graphics and attributes [6-7]. For example, in the field of surveying and mapping, Autodesk Company launched AutoCAD Map 3D product. This product increased "Map data and analysis" menu to deal with graphic information and attribute information at the same time. Custom extensions property fields were predefined as the extended attribute, which can be attached to the graphic entity interactively. In this way user can edit the extended attribute in the same way of editing feature in AutoCAD. After completing this series of operations, professional software or secondary development can be adopted to extract the graphic and attribute information contained in dwg file at the same time, in this way; spatial database building can be realized based on dwg file.

It can be known from the above comparative analysis, extend attribute is the most efficient way to build spatial database based on dwg file. If we adopt AutoCAD 3D software to deal with the extend attribute, the extend attribute fields must be predefined before processing the original data. The extend attribute predefined in dwg file can be used as a template. When you're dealing with the similar projects, the template must be loaded before editing the attribute information. However, spatial database building based on dwg file means the dwg file has been edited. When we open project result dwg file with AutoCAD 3D, the predefined attribute fields can’t be added to the open file. In order to utilize the extended attribute, we must define the attribute fields again. From this scene of view this approach is obviously impractical [8-9]. ArcGIS for AutoCAD can provide a geographic information solution template, which can contain customized extended attribute information that can be loaded by dwg file of the similar projects. Repeated customization the extended attribute can be avoided in this way, it is efficient and convenient to spatial database building based on various historical dwg file.
3. Brief Introduction of ArcGIS for AutoCAD

ArcGIS for AutoCAD is a free plug-in that simplifies the way you share and synchronize GIS content between AutoCAD and ArcGIS. Enrich your CAD drawings with ArcGIS hosted maps, imagery, and geographic features. Edit geographic features within AutoCAD and use them for navigating the drawing through location. ArcGIS for AutoCAD can easily realize the interoperability between CAD data and GIS data [10]. AutoCAD users can use this plug-in to directly access and use the enterprise GIS data and images published by ArcGIS Server in AutoCAD environment. Meanwhile, CAD data can be added as the dataset in ArcGIS for AutoCAD. Due to this special interoperability, a new spatial database building approach based on dwg file was derived by ArcGIS for AutoCAD.

3.1. Installation of Plug-in

The plug-in download address: https://www.esri.com/en-us/arcgis/products/arcgis-for-autocad. AutoCAD software must be pre-installed. User downloads the plug-in according to the version of operation system and AutoCAD software. After downloading the software, double-click the software installation package and follow the wizard to finish the installation.

3.2. Launch the Plug-in

After finishing the installation of ArcGIS for AutoCAD plug-in, a shortcut will be created on the desktop. Double-click the shortcut will automatically load the plug-in after AutoCAD software open. There is another way to launch the plug-in, if you’ve already open AutoCAD software, you can type the "NETLOAD" command in AutoCAD command window and execute the command, and you need to specify the file path of "arcgis for autocad.dll" which located in the plug-in installation directory from the pops up window. You can load the plug-in manually whenever you want to use this plug-in. After the plug-in is successfully loaded, a new menu named "ArcGIS" will be added in the original AutoCAD working environment (as shown in Figure 1), under which all functions provided by the plug-in were integrated.

![Figure 1. ArcGIS for AutoCAD Plug-in integrated in AutoCAD environment](image)

4. Method of Spatial Database Building Base on ArcGIS for AutoCAD

Spatial data database building based on ArcGIS for AutoCAD can be divided into three steps: template making, data making and database building. Each step includes several substeps. The detailed workflow is shown in Figure 2 below.

![Figure 2. Workflow of Spatial Database Building Base on ArcGIS for AutoCAD](image)
4.1. Database Design

Create Enterprise Geodatabase. The result of geodatabase building is the geodatabase with records inside. Therefore, geodatabase structure and tables in geodatabase must be designed and created. ArcGIS software provides a tool named create enterprise geodatabase under ArcToolbox listed in Figure 3. You must have ArcGIS Desktop (Standard or Advanced), ArcGIS Engine with the Geodatabase Update extension, or ArcGIS Server installed on the computer where you'll create the geodatabase. If you're using Oracle or SQL Server, you must also install and configure a database management system client on the computer where the ArcGIS client is installed. When these prerequisites are met, double click the tool in Figure 3 open create enterprise geodatabase window as shown in Figure 4.

![Figure 3. Create Enterprise Geodatabase tool in ArcToolbox](image3.png)

![Figure 4. Parameters setting in Create Enterprise Geodatabase](image4.png)

There are several parameters need to be set, such as the database platform instance database authorization file and so on. After running the tool, the geodatabase is created; you can find the newly created database under database connections in ArcCatalog pane. You can also create the geodatabase in Python window with script below.

```python
import arcpy

arcpy.CreateEnterpriseGeodatabase_management(
    "SQL_SERVER", "localhost", "sde", "OPERATING_SYSTEM_AUTH", "", "",
    "SDE_SCHEMA", "sde", "sde", ",", "c://server101.epc")
```

This script connects to a SQL Server instance (localhost), to create a database named sde and an sde-schema geodatabase in it. The connection is made using operating system authentication. The authorization file named server101.epc located in the root directory of driver C.

Create Dataset in Geodatabase. A feature dataset is a collection of related feature classes that share a common coordinate system. Feature datasets are used to facilitate building controller datasets (sometimes also referred to as extension datasets) such as a topology or utility network. Feature classes that are to be included in an extension dataset are first organized into a feature dataset. Right-click the newly created database in 4.1.1, select New, and click Feature Dataset. Type a name for the feature dataset in the Feature Dataset Name text box. Choose a coordinate system, either by selecting one from the Coordinate System drop-down menu or by clicking the Select coordinate system button next to it and choosing one from the Coordinate System dialog box that appears. Click Run to create the feature dataset.

Create Featureclass in Dataset. Feature classes are homogeneous collections of common features, each having the same spatial representation, such as points, lines, or polygons, and a common set of attribute columns stored in a database table. The four most commonly used feature classes are points, lines, polygons, and annotation (the geodatabase name for map text). This paper takes Wuhan construction project affiliated green land spatial database building as an example. According to the
technical regulation of construction project affiliate green land area measurement, the green land entities should be classified and summarized according to the green land types listed in table 1. Right click the dataset created in 4.1.2, select New, and click Feature Class. Type the name and alias of the Feature Class and select the type of features stored in the feature class. Click Next to Specify the database storage configuration. Next a group of exclusive property fields shall be established for each type of green land entity. In other words, the fields of the table must be determined exactly according to the type of the green land entity. For example, Table 2 shows the property fields designed for the green land scope.

| Feature Code | Layer Name | Content                                      |
|--------------|------------|----------------------------------------------|
| G80101       | YDFWX      | The land use area of the project             |
| G80102       | DXSFW      | The area of underground basement             |
| G80201       | JZQGG      | Residential public green land                |
| G80301       | JZQQT      | Residential other green land                 |
| G80401       | DJZJDB     | Green land at the roof of underground        |
|              |            | construction                                  |
| G80501       | DLRGZJSY   | Water area green land                        |
| G80601       | QM         | Green land with tree                         |
| G80801       | ZCC        | Green land with hollow grass                 |
| G80901       | WD         | Roof green land                              |
| G81001       | CZ         | Vertical green land                          |

| Field Code  | Type     | Length | Description       | required |
|-------------|----------|--------|-------------------|----------|
| 1 GUID      | Text     | 255    | Identify code     | Y        |
| 2 YSBM      | Text     | 50     | Entity code       | Y        |
| 3 YSMC      | Text     | 255    | Entity name       | Y        |
| 4 CQR       | Text     | 50     | Surveyor          | Y        |
| 5 CQSJ      | Text     | 50     | Time of surveying | Y        |
| 6 XCR       | Text     | 50     | People delete the entity | N |
| 7 YCSJ      | Text     | 50     | Time of delete entity | N |
| 8 JSDW      | Text     | 255    | Construction organization | Y |
| 9 XMMC      | Text     | 255    | Project name      | Y        |
| 10 XMBH     | Text     | 255    | Project code      | Y        |

**Table 2. Field Design of Green Land Area Entity**

4.2. **Template Design**

*Create dwg in ArcGIS for AutoCAD.* Open AutoCAD software, the software open a blank dwg file for editing automatically. Save the current open dwg file as a template. Other settings will be added into the template in the following steps.  

*Create Featureclass in ArcGIS for AutoCAD.* Open AutoCAD software. Launch the plug-in, select the "create element class" tool in "ArcGIS" TAB, input the name of the feature class and select the type of the feature class, specify the name and type of the feature class according to the prompts, and add the attribute fields corresponding to 4.1. Once the fields of a feature class were created, you can use ArcMap open the dwg file and check the fields contained in the feature class. Under normal circumstances, a new layer corresponding to the entity will be added to the layer list. The property fields of the layer were the same as that of the new property field in the plug-in.

*Output the dwg File as Solution Template.* Once every feature classes of the green entity were created in a dwg file, the dwg file can be stored as a solution template. This template only needs to be
customized once and can be reused later. Template can also be created by AutoCAD Map 3D, but this kind of template can’t be loaded by a dwg file which already finishes editing. This is the most significant advantage of solution template compare to AutoCAD Map 3D template. That is why we choose ArcGIS for AutoCAD plug-in to extend the attributes in dwg file and realize the spatial data database building base on dwg file in this paper.

4.3. Date Preprocessing

Load the Solution Template. Click "import GIS solution" tool in "management" TAB, specify the template created before. After the solution is successfully loaded, all the elements defined in the template can be seen in the elements drop-down list box in the elements TAB, and the tools that interact with the elements become available.

Identify the Entity Type. Click "feature class properties" tool, you can specify the property items and property values according to layers, colors, linetype, and line width of the feature class, which filters the graphic entities. You can filter graphic entities by appending property values with multiple properties combinations. Since the green land entities of the same type were placed in the same layer in dwg file, therefore layer name can be used as the filter condition to identify the same entity. The Edit the Attribute Interactively. Click the green land entity to choose object, then use "element attribute" tool open attribute edit window (as shown in figure 3) and input the corresponding information. After all entity attribute information is edited, graph and attribute information were saved simultaneously as dwg file saved.

4.4. Database Building

Load Pre-process dwg File. ArcEngine was adopted as the second development tool to realize database building. Feature class in dwg file can be loaded by CadWorkspaceFactroyClass providing by ArcEngine. Then graph and attribute information can be obtained by iterating the entity [11]. The relevant code is as follows:

```csharp
IWorkspaceFactory pWorkspaceFactory;
IFeatureWorkspace pFeatureWorkspace;
IFeatureLayer pFeatureLayer;
IFeatureDataset pFeatureDataset;
pWorkspaceFactory = new CadWorkspaceFactoryClass();
pFeatureWorkspace=(IFeatureWorkspace)pWorkspaceFactory.OpenFromFile(dwgfiledirectoryPath, 0);
pFeatureDataset = pFeatureWorkspace.OpenFeatureDataset(dwgfileName);
IFeatureClassContainer pFeatureClassContainer = (IFeatureClassContainer)pFeatureDataset;
for (int i = 0; i < pFeatureClassContainer.ClassCount - 1; i++)
{
    IFeatureClass pFeatureClass = pFeatureClassContainer.get_Class(i);
    if (pFeatureClass.FeatureType == esriFeatureType.esriFTAnnotation)
    {
        pFeatureLayer = new CadAnnotationLayerClass();
    }
    else
    {
        pFeatureLayer = new FeatureLayerClass();
        pFeatureLayer.Name = pFeatureClass.AliasName;
        pFeatureLayer.FeatureClass = pFeatureClass;
        axmapcontrol.AddLayer(pFeatureLayer)
    }
}
```

Graphic and Attribute Database Build Simultaneously. For some special application scenarios, we not only pay attention to the drawing effect of dwg files, but also focus on the content of element coding system, attribute information input, topological relations and so on. Data quality inspection including
mathematical accuracy, attribute accuracy, structure correctness, and topological relationship and so on should be carried out before records insert into the database [8]. All the check rules were list in a configuration file and can be modified in different circumstances. The check result output as excel format, which make it easy to use. Enterprise geographic database should be created first, in the database all feature classes should be created according to 4.1.2. Then graphic and attribute information can be extracted from dwg file simultaneously by ArcEngine.

Custom Spatial Data Management. Once the records inserted into the enterprise geographic database, various spatial data management functions can be developed on demand. Figure 5 and figure 6 represent the effects of displaying and querying attribute information based on the development of spatial database.

5. The Development Case
In this paper, Wuhan construction project auxiliary green land database building based on ArcGIS for AutoCAD plug-in was took as an example (Figure 5). Visual studio 2010 C# and Microsoft SQL Server were adopted as the integrated development environment language and database software. With the help of ArcGIS for AutoCAD plug-in, graphics and attributes can be managed synchronously in dwg files. Figure 6 is the project attribute information contained in featureclass. Figure 7 is the statistical information of various kinds of green land entries.
6. Conclusion
Dwg file, as a common data format of DLG, has been widely used in the field of surveying and mapping. This file focuses on the effect of graphics, but the ability to manage the attribute information of graphics entities is very weak. In this paper, with the support of ArcGIS for AutoCAD plug-in, we can edit graphic entity in AutoCAD environment and input attribute information at the same time, which realize the integrated storage of graphs in dwg file. Then we combined C# with ArcEngine for secondary development to extract graphics and attribute information quickly and accurately, which stored in dwg file to complete the spatial data building. This kind of dwg file contain both graph and attribute information, which can also be extracted and imported into spatial database by FME software [12].ArcGIS for AutoCAD plug-in supports reading GIS solutions from an existing dwg file, therefore it is very suitable for processing historical mapping results in dwg format. The software developed in this paper has been applied in the database building of green land, pipeline and topographic surveying and mapping results and it will be gradually applied to the database building of other types of surveying and mapping results.

7. References
[1] Luo H Y and He J. Design and realization if Vector database construction base on CAD platform. 2016 Bulletin of Surveying and Mapping 6 105-8.
[2] Sun Y and Luo X P. Data exchange between AutoCAD and ArcGIS based on DWGDirect. 2009 Computer Engineering and Design 7 1753-55.
[3] Li W W, Xu Q L and He J. Technology research of basic geology information data building based on CASS. 2014 GeoSpatial information 12 56-8.
[4] Li T W and Zeng H Z. Design and implementation of surveying and mapping production management system based on ArcGIS. 2009 Urban Survey 1 34-7.
[5] Zhu W Y and Zhang J Q. Discussion of CAD file to GIS data database. 2007 The fourth Yangtze river delta BBS - mapping BBS 128-31
[6] Yang L L, Zhang X C and Huang J F. The technology and research on regularization and transformation of CAD planning data for GIS spatial database. 2015 Bulletin of Surveying and Mapping 6 44-8.
[7] Zhang M, Zheng F J, Shi M, Li P P, Wei Z F and Zhou Xu. Methods of quality inspection of spatio-temporal DLG data based on Weisi2.0 2018 Urban Geotechnical Investigation & Surveying. 6 37-40.
[8] Sun L and Li L. The method of checking the consistency of DLG data before and after building a database in basic surveying and mapping.2012 Urban Geotechnical Investigation & Surveying. 2 68-71.
[9] Yi Y Z and Feng Y. The rapid realization of surveying data transform based on AutodeskMap.2009 Geomatics & spatial information technology. 2 70-4.
[10] http://resources.arcgis.com/zh-cn/help/arcgis-for-autocad/
[11] Qiu H G, Zhang Q L and Lu S Q. ArcGIS Engine development from beginner to proficient 2010 Beijing Posts & Telecom Press
[12] Li K. Research on the application of FME in the construction of basic geographic information database. 2016 Bulletin of Surveying and Mapping 3 115-7.