

Development of a Precision Agriculture Tool Suite Using ArcPad

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Abstract

The field collection of data for precision agriculture applications is well suited for a handheld computer connected to a GPS receiver. An integrated suite of data collection tools has been developed by the University of Kentucky based on ArcPad 6 technology using ArcPad Application Builder. The tool suite includes field boundary and feature mapping, crop scouting features, grid soil sampling tools, and nutrient and pesticide application logging.

Introduction

The benefits of implementing precision agriculture practices include increased profits through increased efficiency, reduced agronomic inputs, improved production decision, reduced environmental impact, and better record keeping (Stombaugh et al., 2001). The effectiveness of implementing best management practices through sub-areas of a field is dependent on the quality of the data collected and the ability to manage and analyze that data. As with many new technologies, implementing precision agriculture solutions can be a significant capital investment. Important factors that should be considered in selecting initial equipment is ease-of-use, flexibility to use the equipment for a variety of tasks, and the capability to upgrade the equipment to incorporate new technologies in a cost-effective way.

Basic mapping and field-level record keeping is one of the first precision agriculture practices that should be implemented in a typical production agriculture operation (Stombaugh et al., 2001). Typical tasks include mapping of field features such as the boundary, drainage swales, drainage tile, sinkholes, rock outcropping, utility lines, and historical features. By tracking tractor and implement movement throughout a field, a producer can record information about herbicide, pesticide, and fertilizer application. While this can be important in future years by having historical production records, increased regulatory pressures might make this a necessity for all producers applying regulated chemicals and fertilizers to their fields.

Another precision agriculture operation that is typically implemented early on farms is site-specific soil fertility sampling. Grid sampling involves taking samples at points on a square grid throughout a field. When laboratory analysis information is added to the grid locations, a soil fertility map can be created to identify management zones within a field. This information can be utilized to create input data for variable-rate chemical and fertilizer application and variable seeding.

Use of Handheld Computers for Data Collection

Handheld computers can be a cost-effective and convenient tool for basic mapping and data collection tasks commonly performed for precision agriculture practices. With the improvement of handheld global positioning system (GPS) receivers, producers can collect, analyze, and store information about their fields with a system that can fit in their pocket. The major benefit of handheld computers is their size and portability, but a major limitation is the screen size and quality.

ESRI's ArcPad

ArcPad is ESRI's solution for database access, mapping, GIS, and GPS integration for handheld and mobile devices. ArcPad is integrated with ESRI's ArcGIS desktop software and provides file management features that allow use of existing shapefiles in the field as well as the capability to upload data obtained in the field into the database located at the office. Key features of ArcPad include support for industry-standard data formats, display and query functionality, editing and data capture, and optional GPS plug-in capability, all using a simple and modern interface (ESRI 2002).

Another key feature of ArcPad is the availability of a development framework for creating custom solutions for mobile data collection systems. Customization of ArcPad is performed using the ArcPad Application Builder software, a desktop software package. ArcPad Application Builder allows developers to:

- create new toolbars that contain standard and custom tools
- design custom forms to allow for more efficient data collection
- write scripts that interact with ArcPad's internal software objects
- build applets that are a collection of tools and scripts for a custom task, and
- develop extensions to support new file formats and positioning services

The customization is usually performed on the desktop and then deployed to a mobile device (ESRI 2002).

Creating the Tool Suite

In creating the precision agriculture tool suite, the objective was to demonstrate the capability of the ArcPad software program to perform common data collection tasks associated with precision agriculture practices. The level of complexity of the customization has the potential to be very advanced. This applet can be considered intermediate in complexity because of the combination of custom toolbars, forms, and scripts.

The following sections describe the individual tools that comprise the applet.

File Management

One task in ArcPad that can be time consuming and tedious, especially in the field, is the creation and management of shapefiles. In creating a tool suite for field use, file management is a major part of the custom solution. Since each of the precision agriculture tasks performed is directly related to a particular field on a farm, the file naming and management scheme utilizes a user-defined name of the field. For each shapefile associated with a particular field, the filename contains the name of the field (eg. Field53-boundary.shp).

The first button on the custom toolbar opens a multiple page form that allows the user to select a field to use, create a new field, or delete a field. When the Field form opens, the Select page is displayed (Fig. 1) and a list box containing the existing fields is populated. This is done by searching for database files named fieldname-fld.dbf that are present for each field. When an existing field is selected, the associated shapefiles (boundary, scouting features, etc.) are loaded and displayed in the map area.



Figure 1 - "Select" page of the "Field" form.

To create a new field, the New tab is selected to display the New page of the Field form (Fig. 2). On this page, the name of the new field must be inputted using the keyboard or soft input panel of the device. The projection that will be associated with the field must also be selected. Each file that is created for the field will use the selected map projection. Initially a database file is created for the new field and additional files are created as the tools are utilized.



Figure 2 - "New" page of the "Field" form.

To delete a field and its associated files, the Delete tab is selected to display the Delete page of the Field form (Fig. 3). A list box containing the existing fields is populated and shown. When a field is selected to be deleted a dialogue box is shown to make sure that the field selected should be deleted. It should be noted that the PocketPC operating system does not have an undelete or Recycle Bin feature to undo the delete operation. Once the dialogue is cleared, all of the files associated with the selected field are deleted.



Figure 3 - "Delete" page of the "Field" form.

Boundary Mapping

One of the most common tasks that would be performed with this tool suite is mapping the boundary of a field using a GPS receiver. The second button on the custom toolbar opens a new Boundary custom toolbar (Fig. 4). When this toolbar is opened, a polygon shapefile named fieldname-boundary.shp is created to store the field boundary. The common tools that

would be used to create the boundary are located on the toolbar. The first button activates the GPS if it is connected and properly configured. The next button creates a polygon feature and the third button starts and pauses the streaming collection of GPS points as vertices of the polygon. The create polygon button is clicked again to close the polygon feature. No attributes are saved in the shapefile for the field boundary.

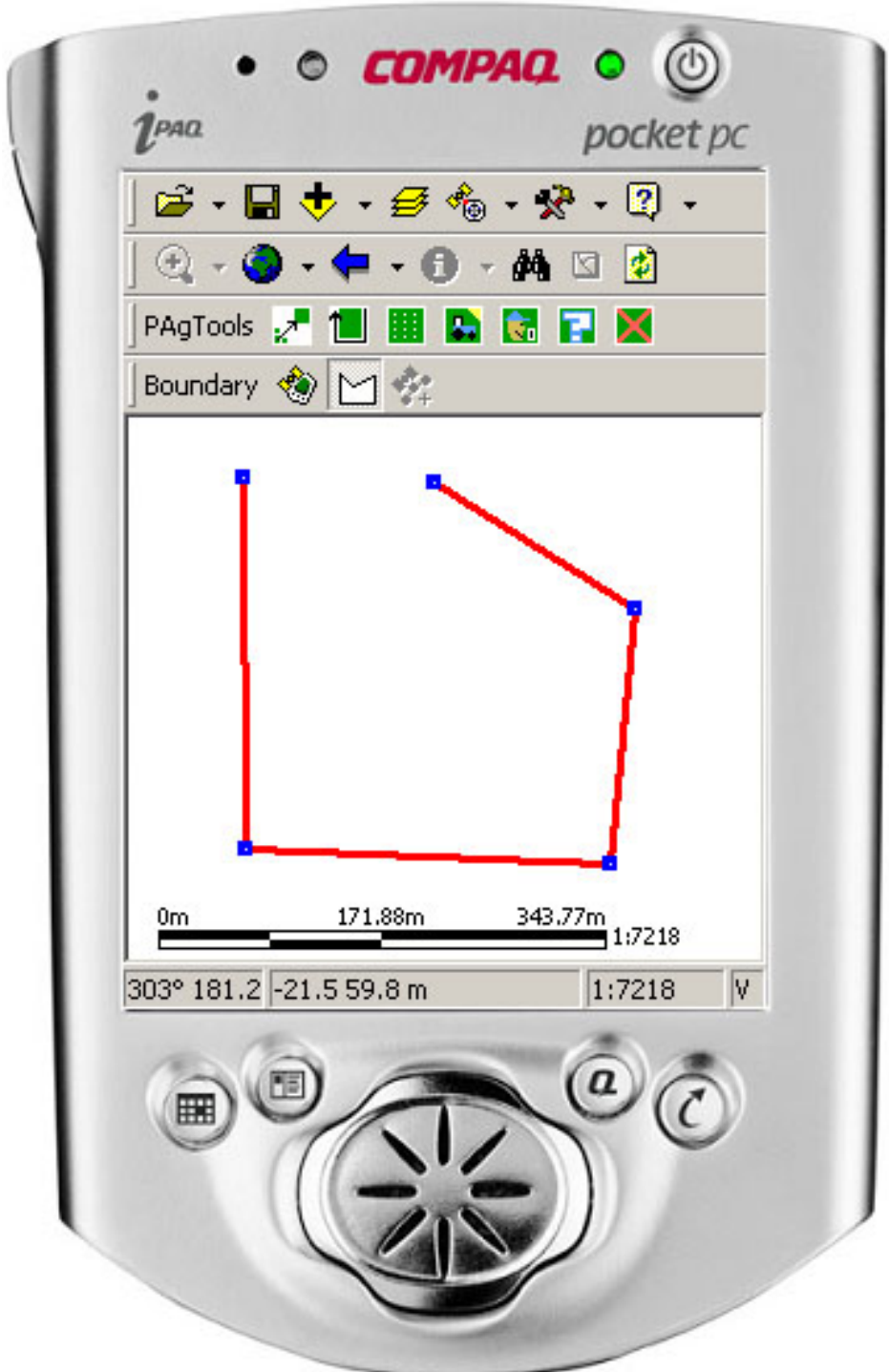


Figure 4 - "Boundary" toolbar.

Grid Sampling

The next tool available on the custom toolbar is the grid sampling tool. The third custom button acts as a toggle for the grid of the field. If a grid does not exist for the selected field, the Grid form will be loaded and displayed so that the parameters for the grid can be entered (Fig. 5). If a grid already exists when the button is clicked, the user is prompted to either display the existing grid (Fig. 6) or create a new grid.

The Grid form allows the user to input the X-axis and Y-axis intervals of the grid that is being created. The units that are shown on the form depend on the units of the projection selected when the field was created.



Figure 5 - "Grid" form.

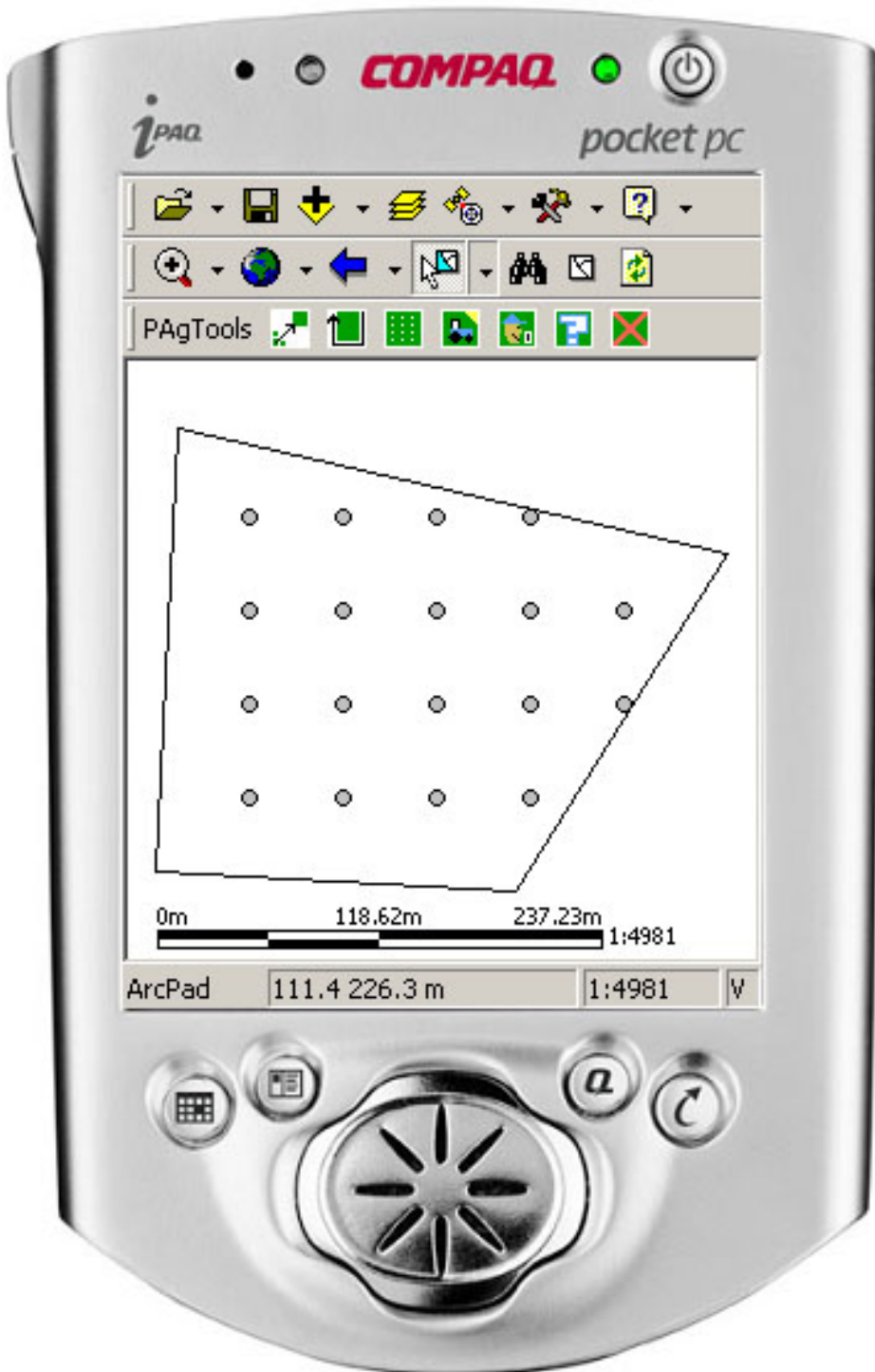


Figure 6 - Field with grid points shown.

Field Operations Logging

The fourth tool in the suite allows the recording of field operations such as planting, harvesting, and the application of fertilizer, pesticides, and herbicides. The fourth button of the custom toolbar opens the Field Operations form. From this form, the user can display, delete, or create a new field operation.

When the Field Operations form opens, the Show page is first displayed (Fig. 7) and a list box containing the existing field operations is populated. When an existing field operation is selected, the associated shapefile is loaded and displayed in the map area.



Figure 7 - "Show" page of "Field Operations" form.

The New page of the Field Operations form contains an input box for the name of the new field operation. When the Create button is clicked, a new shapefile is created based on a template database file. A layer definition file is also created based on a template file. Attributes such as description, equipment, operator, implement width, and date are created for the new shapefile and are entered by the user on the New Field Operation form (Fig. 8).

The common tools that would be used to map a field operation are the displayed on a new custom Field Operation toolbar. The first button activates the GPS if it is connected and properly configured. The next button creates a polyline feature and the third button starts and pauses the streaming collection of GPS points as vertices of the polygon. The create polyline button is clicked again to close the field operation feature.





Figure 8 - "New Field Operation" attribute form.

To delete a field operation, the Delete page of the Field Operations form is opened and a list box is populated with the names of the existing field operations. When a field operation is selected to be deleted, a dialogue box is shown to make sure that the field operation should be deleted. Once the dialogue is cleared, the shapefile and associated files are deleted.

Scouting

The last tool on the custom toolbar is the Scouting toolbar (Fig. 9). This tool is similar to the Grid tool in that the custom button acts as a toggle for the mapped scouting features of the field. When the scouting tool is selected for the first time, three shapefiles are created to contain the mapped features: `fieldname-scouting_pt.shp` (point shapefile), `fieldname-scouting_pl.shp` (polyline shapefile), and `fieldname-scouting_pg.shp` (polygon shapefile). If the scouting polylines already exist, the files will be shown and made editable. The common tools that would be used to map features in the field are available on the Scouting toolbar including point, line, and polygon creation as well as GPS add point, add vertex, and add streaming point.



Figure 9 - "Scouting" toolbar.

Other Features

The sixth button on the custom toolbar, the Help button, launches a Help file in Internet Explorer. The help file is in html format and contains a simple description and basic instructions for the tools.

The Exit button is the last button on the custom toolbar. This button simply closes all of the

open shapefiles and exits ArcPad. Since the field selection tool will open the selected field and associated shapefiles the next time ArcPad is launched, there is no need to save the map.

Plans for Future Development

The implementation of more advanced tools for scouting would be a major improvement of the tool suite. Lookup lists containing common items and phrases that would be used during crop scouting could be selected on custom forms making data entry in the field more efficient.

Conclusion

This precision agriculture tool suite created as an applet for ArcPad is an example of a cost-effective and convenient tool for basic mapping and data collection tasks commonly performed for precision agriculture practices. The benefits of a tool like this include increased profits through increased efficiency, reduced agronomic inputs, improved production decision, reduced environmental impact, and better record keeping.

References

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