PEGGER & ROADVIEW - A New GIS Tool To Assist Engineers In Operations Planning

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ABSTRACT - By evaluating alternative routes in the office using a pegging routine, days or even weeks can be saved of valuable field time and ultimately, a better design can emerge. Initial road design in forested landscapes often includes pegging roads on large-scale contour maps with dividers and an engineers scale. An automated GIS based road-pegging tool (PEGGER) was developed to assist in initial road planning by automating the road pegging process. PEGGER is an extension for the commonly available GIS software Arcview®. PEGGER imports topography as digital contours. The user identifies the origin of the new road, clicks in the direction they want to go and PEGGER automatically pegs in road at a specified grade. Through the use of PEGGER, many alternatives can be quickly analyzed for alignment, slope stability, grades and construction cost using standard GIS functionality. The resulting cuts and fills are then displayed in ROADVIEW, a road visualization package for Arcview®.

This paper looks at the algorithm used, evaluates it's usefulness in an operations planning environment and suggests additional methods which might be incorporated into PEGGER to further assist the forest engineer.

Keywords: Road pegging, timber harvest planning, road location, road design, forest road location, computer automated road design, rural technology

INTRODUCTION

A computer program is presented that automates initial forest road location through the use of a Geographic Information System and digital terrain data. Using PEGGER, forest planners can quickly analyze many road location alternatives and, by taking advantage of standard GIS functionality, evaluate environmental and economic opportunities.

BACKGROUND

Traditional methods for designing a forest road system consisted largely of aerial photo interpretation and field reconnaissance. More recently, forest engineers have used large-scale contour maps to select preliminary routes with dividers, a process known as route projection or "pegging". According to Pearce (1960), "Route projection is the laying out of a route for a road on a topographic map of aerial photo. The route defines the narrow strip of land within which the field preliminary survey is made." This trial and error method of initial paper based road location has proven itself as a cost effective method for preliminary design and analysis by avoiding intensive field investigations.

With the overwhelming popularity of Geographic Information Systems (GIS) in natural resource management it is appropriate to explore opportunities to integrate traditional road design techniques into the GIS. With the availability of free 10-meter digital elevation data for the United States and the continually decreasing cost of LIDAR data it is possible to extend the road pegging technique to include a more detailed analysis.

EXISTING MODELS

While many road design packages exist (RoadEng, AutoCAD, F.L.R.D.S…) only one has given the user the ability to quickly look at alternative road locations at varying scales, ROUTES (Reutebuch, Stephen E. 1988). Traditional road design software relies on survey data collected in the field to generate terrain models and very detailed engineered road location and construction plans. Others have taken a more holistic approach and looked at optimization of road locations for a particular set of topographical, environmental or economical constraints (Xu 1996, Thompson 1988, Wijngaard and Reinders 1985, Cha, Nako and Watahiki 1991). All these programs have relied on a high degree of training on the part of the user and few of the non-commercial packages have matured into an easy to use software package.

ROUTES was developed to automate the road pegging process. Using a large-scale contour map (1in = 400ft) and a digitizer, the user could digitize the contours and use the digitizer puck to locate the road. While the user interface was primitive consisting of high and low pitch beeps from the digitizer puck to signal that the user was “on-grade”, the program worked well and kept track of such things as grade, road length and stationing. ROUTES reliance on a digitizer, it’s HP 9000 code base and the general lack of a graphical user interface (GUI) left the program without many users.

THE PEGGER PROGRAM

With the growing availability of LIDAR and IFSAR data, locating roads in the office is becoming a more realistic and practical exercise. Within the GIS framework many tools exist to locate geographic features, examine spatial relationships among natural elements and act as a foundation for a decision support system. Watson and Hill (1983) define a decision support system as an “interactive system that provides the user with easy access to decision models and data in order to support semi structured and unstructured decision making tasks.” It is with the intention of providing an initial decision support system that PEGGER was developed.

PEGGER is an Arcview® GIS extension that automates the route projection (“road pegging”) process for use by engineers and forest planners. PEGGER imports topography as digital contours much like using a paper contour map. Standard tools available within Arcview GIS allow the user to import the contours from Shapefiles, ESRI coverages, AutoCAD dwg and dxf, and Microstation dgn files. In addition to importing data as digital contours, users can use the Arcview Spatial Analyst extension or other publicly available tools to convert USGS digital elevation models to contours.

One of the goals of the PEGGER project was to make the program as usable as possible for as many people as practical. One of the problems with technology is training users to use the software. Forestry professionals responsible for fieldwork have been slow to adopt new technology into their work largely due to the complexity of the software and the time commitment of training. The PEGGER program was designed to avoid these common pitfalls, requiring no training, minimal setup time and a simplified user interface. Included with the software are a detailed help file and complete tutorial.

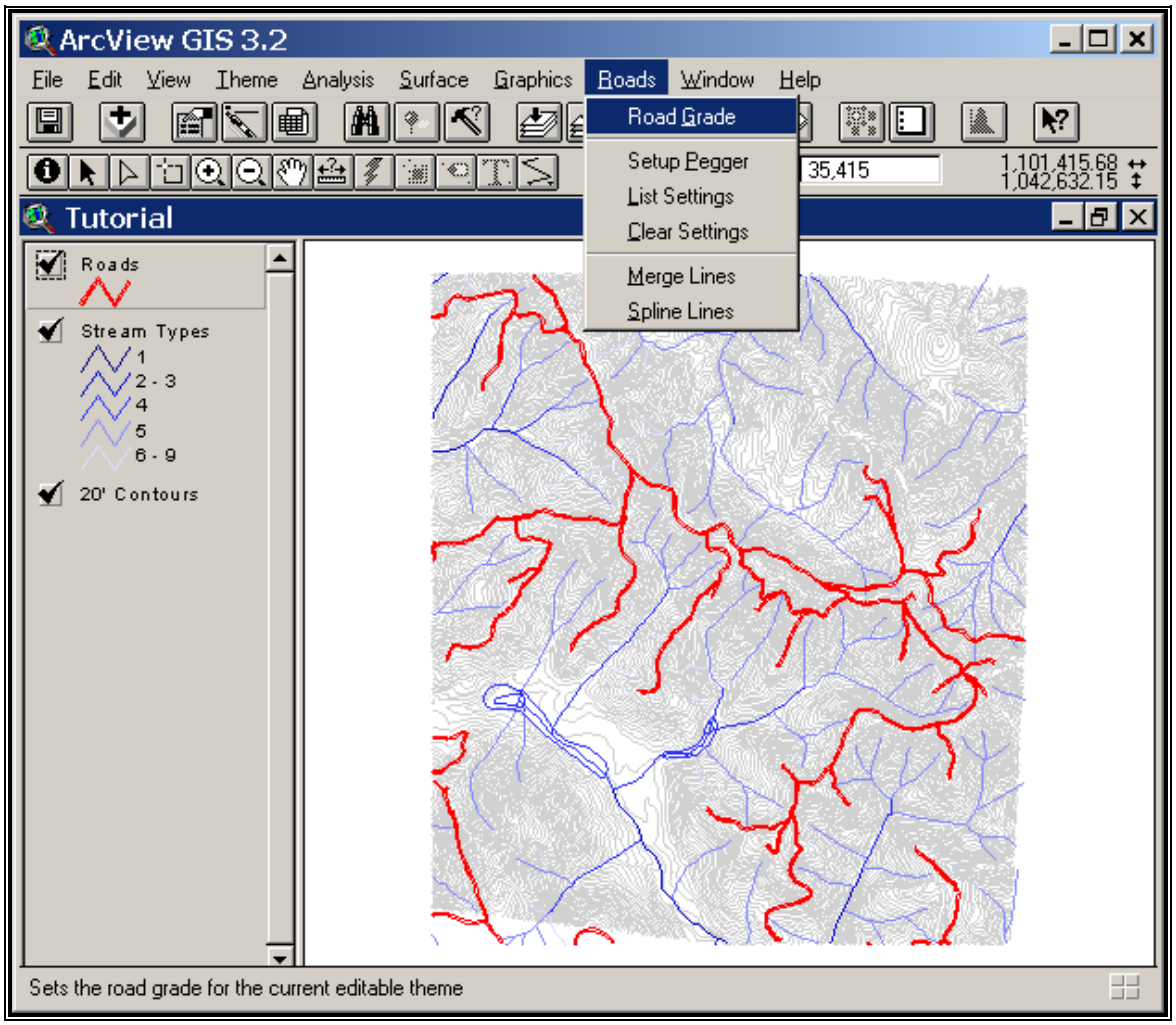

Figure 1 - The simple PEGGER interface in Arcview GIS

Once digital contours have been imported into Arcview the user must supply a few parameters, the road theme they would like to edit, the contour theme they would like to use as well as confirm the detected contour interval. In addition to the contour and road themes the user can have any number of other layers available in the GIS such as soils, slope classes, streams, wetlands, unstable slopes and property lines. The next step is to locate the desired beginning and/or endpoints of the new road given operational parameters. Using standard tools available in the GIS (ruler and identify) the user can estimate the necessary grade for the road.

To start a road the user shift-clicks on the location where they wish to begin and enters the desired grade. To “peg” the road the user only has to click in the general direction they wish to go in order to project the route into the GIS. Successive clicks peg in additional segments of road from contour to contour as fast as the user can press the mouse buttons. Grade changes can be accomplished by using the Roads pull-down menu or by right clicking the mouse and selecting Increase or Decrease Grade.

If the road fails to reach the desired end point, the previously pegged segments can be quickly deleted and a new grade can be tried. This method of trial and error that used to mean changing

the divider spacing and erasing undesirable segments from the map can now be accomplished in the GIS in a fraction of the time.

ANALYTICAL DESCRIPTION

PEGGER works by identifying contour lines that meet a specific set of criteria. Every projected route segment must begin and end on a contour line. To project a segment the user enters a desired grade and PEGGER looks for a point on an adjacent contour line at a distance computed by:

$$d = ci / (g / 100)$$

where d = the distance,
ci = the contour interval, and
g = the desired grade.

NOTE: For pegging on paper maps, the distance would need to be multiplied by the map scale (ie: 1/4800) to get the appropriate divider width.

If a point is found, a new route segment is created in the GIS. If a point is not found, the user is notified that the desired grade is not feasible and potential solutions are proposed. Unlike ROUTES, which allowed for a grade tolerance (+/- some tol), PEGGER gives an exact solution in the GIS. After a desirable route location has been found the user can attach the grade attributes to the route segments, merge the segments into one long road or spline to smooth sharp corners (much like a finalized design).

LIMITATIONS

The PEGGER program relies on digital topographic information to identify potential road locations. To be of value to the forest professional, the topographic information must accurately represent the actual ground conditions. Steve Reutebuch noted about ROUTES that “the accuracy of the 30-meter (USGS) DEM’s available at the time were insufficient for accurate route projection.” With the availability of 10-meter digital elevation data and the current popularity of LIDAR data, route projection has become more feasible but discrepancy between the data and actual field conditions should be expected.

The PEGGER program is a tool for quickly identifying possible route location alternatives given grades specified by the user. The tool does not evaluate additional environmental and economic constraints that must be considered by the forest professional such as soil types, hydrology, property lines and slope classes. The GIS provides a framework where these analyses can be implemented but it is outside the scope of the PEGGER program.

NEXT STEPS

In addition to providing quick alternative location analysis, PEGGER should be extended to include some additional functionality. With greater availability of high resolution digital elevation data it will be possible to identify a route location or P-Line (preliminary location line) using PEGGER and then “survey” the surrounding area for export into a road design package like ROADENG or AutoCAD. This digital survey within the GIS can be used to generate the topographic information and field notes necessary to do a complete design in the road design

package. The final L-Line (location line) and slope staking notes can be generated using the GIS and the road design package for use in the field by the forest professional.

Figure 2 - ROADVIEW visualization of a route located with PEGGER

Complementing PEGGER is a companion program ROADVIEW that takes the preliminary route location generated by PEGGER and creates a 3-dimensional model of the road's cuts, fills and running surface. Using the 3-D model and a visualization program such as EnVision, professionals can look at the road as it might be constructed and effectively communicate with non-forest professionals regarding scenic and environmental impacts.

CONCLUSION

While route location has been used by forest professionals for many years and computerized in the 1980's with the introduction of ROUTES, it has never become a widely used technology to evaluate initial road locations. With PEGGER, the forest planner can quickly evaluate route locations within a GIS framework, giving the planner access to additional GIS functionality. PEGGER was designed with simplicity and minimal investment cost as primary objectives. Through the use of a carefully designed user interface and extensive tutorial, a typical user can be locating roads in a few minutes on their own PC taking full advantage of forest technology.

ONLINE

For more information about Pegger and to download the Arcview® extension visit http://www.ruraltech.org/tools/pegger/

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