Deploying ArcGIS Engine for tailored analyses in nature conservation

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Abstract – Nowadays biodiversity research and management of natural resources should include also those analyses which consider spatial information. However, complex analysis or even processing chains are not readily available in standard GIS packages and hence require customisation. ArcObjects provides numerous GIS API which facilitate the development of a focused light-weight GIS by means of ArcGIS Engine. Here, the API considerably reduce the implementation time for setting up such an application. Besides the implemented functions for geodata analysis and visualisation the developed BiotaEastGIS Tool comprises a comprehensive help system as well as a simple GUI allowing for a straightforward consideration of the spatial context in biodiversity research and management even by so-called non-GIS professionals. The array of functions is based on eight years of integrated biodiversity research experiences within the BIOTA East Africa project. A first training of people from the African counterpart institutions on the beta version revealed its high potential.

Keywords: ArcObjects, .NET, customised GIS, biodiversity research and management

Extended abstract: Ecological studies involving the analysis and prediction of change in natural resources have focused on natural reserves conservation. Here, an important aspect is the maintaining of the various ecosystem services such as provisioning services, regulating services, cultural services and supporting services (Millennium Ecosystem Assessment, 2005). Keystone species are considered important in conservation as they contribute most to the functioning of an ecosystem (cf. Garibaldi and Turner, 2004). Human disturbance on the biodiversity resources and excessive or even unsustainable consumption of ecosystem services, however, have influenced natural reserves adversely (Chivian, 2002). Ecologists often use different parameters for measuring these influences. Here, physical/abiotic environmental parameters such as elevation, temperature, precipitation influence species distribution (cf. e.g. Lloyd and Palmer, 1998) and are often ascribed together with other biotic observations. A distance matrix calculated for the observations' locations often builds the basis for the required testing for spatial autocorrelation (e.g. Farwig et al., 2008). The proximity of a study location to e.g. forest edge has been used in studies related to species richness and abundance (e.g. Berens et al., 2008). Knowledge on habitat type at specific locations or quantified composition of different land-cover/vegetation types at the patch or even class level allows conjecturing habitat characteristics (e.g. Steffan-Dewenter et al., 2002). In this context GIS as a special tool to handle spatial data is often employed to perform analyses considering spatial information.

Mature desktop GIS software comes with a bulk of spatial functions of which some could be useful in biological/ecological analyses. However, for people who are not familiar with GIS or with only

limited knowledge on GIS but in need of applying complex spatial analyses, it is somehow difficult to find the desired functions within these systems. This is in parts related to the fact that GIS has its own terms and terminologies. A simple example of spatial analysis (e.g. overlay operations) for vector data may be performed by functions as ‘clip’ or ‘erase’ while for raster data the same task is performed via cartographic modelling applying local, focal, zonal or global operations (cf. Tomlin 1991). So people who are less acquainted with GIS keywords have not only to learn GIS terms before they are able to make proper use of the software, but also at least a limited understanding of the different data models and methods is required. Another option would be sophisticated customisation with a simple to handle GUI to ‘conceal’ the differences. Thus customised and focused GIS tools are the solution to such problems, which allow the researchers to focus on their primary tasks but nevertheless to allow the use of GIS in their work (Ojha et al., in prep.).

Existing application programming interfaces (API) such as ArcObjects or Geotools provide GIS-developers easy access to GIS functions for their implementation in robust tailored GIS applications in very short periods of time. GIS API facilitate accessing spatial and non-spatial databases directly or via Application Bridge from within the program and may simplify the process of controlling GIS interfaces (Keller and Strapp, 1996). Many specialised GIS functions and object libraries are available in ArcObjects. These libraries can be used in an optimised way for providing specific tasks (Hu 2004). ArcObjects, as the centre for customisation of ArcGIS applications, can be used to manipulate ArcGIS Desktop, build custom applications with ArcGIS Engine, to develop enterprise GIS application or / and services using ArcGIS Server (GIS server) as well as Mobile GIS applications (ESRI, 2004). Customising the ArcGIS Desktop can be done using scripts and macros, but specific knowledge is required to implement complex functionalities. The development environment of ArcGIS Engine offers developers the core GIS functions and objects when specifically developing a standalone GIS tool. This is highly preferred when implementing applications with specific functionalities within a graphical user interface (GUI) that is simple to use.

Based on eight years of integrated biodiversity research within the BIOTA East Africa project, we (subproject E02) have developed a GIS-based tool implementing an array of functions for geodata analysis and visualisation incorporated in a simple GUI and aided by a comprehensive help system (Ojha, 2007). This allows users a straightforward consideration of the spatial context in biodiversity research and management even in case of so-called non-GIS professionals. The BiotaEastGIS Tool is implemented using ArcGIS Engine as GIS library and Visual Basic (VB) .NET as programming language. VB has been chosen as it is one of the most popular programming languages among rapid application development environments for MS-Windows systems, more so because of its being easy to learn in short time. The tool is realised with specific functions proved to be of particular importance for providing spatial context in biodiversity data analysis or forest ecosystem geodata management

within the BIOTA East Africa project. Besides, it has been implemented to suit the needs of non-geoprofessionals by serving specific requirements: The GUI offered by the tool is intuitive to grasp and apply. The help system provides the user a step-by-step 'guidance' on functions (use and concepts). And, the tool is to support standard vector and raster data formats. The ability to open and save ArcGIS map documents (MXD files) adds flexibility for its use in combination with ArcGIS Desktop applications.

The analysis functions in the tool comprise the topics of geodata creation, geodata analysis chains and geodata description. The geodata creation functions include 1) import of GPS readings as points, lines and polygons, and 2) designing plots (of points, transects, polygons) with reference from single known points (e.g. available GPS readings). The geodata analysis chains incorporate 3) generating a distance matrix for points or polygons, 4) determining distance to edge also considering here the location of the points (inside, outside or edge), 5) calculating a relative distance to edge index, 6) extracting values from a surface raster (for points, transects, polygons), 7) calculating land cover proportions within (multiple buffered) features, and 8) determining habitat at multiple points including an uncertainty judgement. The functions for describing geodata, which are useful for metadata creation, are 9) find percentage of area covered by a layer (geodataset) with reference to e.g. a study-area, 10) calculate layer extents (in deg-min-sec) and 11) export layer preview image. Apart from these functions, the tool also facilitates the visualisation of geodata providing 5 functions for map creation (adding a title, legend and scale bar), map printing and exporting as an image file. For easy use of the tool, a context sensitive and comprehensive help system is integrated within the tool. It includes information on map projection and converting coordinates in deg-min-sec to decimal degrees, topics with which biologists often struggle. The help system is, wherever applicable, extensively making use of illustrations explaining the functions and concepts used.

The first introduction of the BiotaEastGIS Tool (beta version) outside the subproject E02 was made as part of a beginners' GIS training for members of the African counterpart institutions and the tool proved to run stable. Here, the usability of the tool has been tested where the trainees found it easy to handle and useful for their work. They got very much excited with the prospect of being able to soon perform such GIS analyses independently but with ease by making use of the BiotaEastGIS Tool. At the same time we are indirect beneficiaries because those users are becoming less dependant on us for GIS related work for which we are currently providing support. The tool is now ready to be released and it will be made available for free soon.

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