Chapter 21

THE GEOMETRY OF LINE-OF-SIGHT AND WEAPONS FAN ALGORITHMS

Peter L. Guth

US Naval Academy

Abstract: Intervisibility algorithms, when applied to digital elevation models, are used to compute line-of-sight, weapons fans or viewsheds, and accurate three-dimensional perspective views. Whereas data quality, atmospheric effects, vegetation, and buildings contribute to the final result, the geometric model has a major impact. Seven geometric parameters should be explicitly defined: Viewer and target locations, interpretation of viewshed, point interpolation, point selection along radials, viewshed creation, vertical earth curvature, and horizontal earth curvature. The importance of horizontal earth curvature - the determination of straight line distance between observer and target - has not been sufficiently appreciated. Unless Universal Transverse Mercator approximations are valid, geodetic computations should be used. Because digital elevation models available to the military typically have a geographic-based point spacing, many established procedures that implicitly assume a conformal Universal Transverse Mercator grid introduce errors. A spaced radial algorithm produces the best weapons fans.

Key words: line-of-sight, weapons fans, viewshed algorithm, digital elevation model, intervisibility

1. INTRODUCTION

Much of the military’s interest in terrain analysis concerns intervisibility, because weapons, communications, and detection systems require line-of-sight (LOS) for light, radio, or radar waves. Intervisibility can be defined as a “...function which calculates area or line-of-sight which can be ‘seen’ from a specific location or locations” (Defense Mapping Agency, 1994, 131). Simple intervisibility or LOS computations determine whether two points can see each other and more complex products simultaneously display
a number of computations in a weapons fan or viewshed (Lee, 1991). Accurate intervisibility computations can create three-dimensional (3-D) perspective views of terrain, with graphic visualizations realistic enough to measure positions. Intervisibility also figures in many military models and simulations.

The importance of LOS (Fig. 1A) and weapons fans (Fig. 1B) has been recognized since the work of the great French military engineer Sébastien Le Prestre de Vauban (1633-1707). Military historians and geographers also recognize the importance of intervisibility analysis in understanding past operations. Published examples include the defense of West Point in the

![Figure 1](image-url)

*Figure 1. A. Diagrams from Vauban showing an early depiction of the military importance of line-of-sight and B. A portion of a map of the siege of Ath in 1706, showing attacking batteries and their fields of fire. From Vauban, 1828-29, Plates 6 and 10.*