APE: Anti-Poaching Engine

V.S. Subrahmanian
Lab for Computational Cultural Dynamics
Computer Science Dept. & UMIACS
University of Maryland
vs@cs.umd.edu
www.cs.umd.edu/~vs/

Joint work with Noseong Park, Edoardo Serra, and Tom Snitch
Talk Outline

• Motivation: Reduce Killing of Elephants, Rhinos, and other Endangered Species

• Approach
  – Data
  – Animal Behavior Models
  – Poacher Behavior Models
  – Algorithm

• The APE System
Motivation

- Over 2 rhinos killed per day in S. Africa alone
- Majority in Kruger National Park
- 96 elephants killed per day in 2012
- This is a crisis.

Source: http://www.savetherhino.org/rhino_info/poaching_statistics
Data

• 2 years of data, recorded on a daily basis, from Olifants West Reserve in South Africa near the border with Mozambique.
• Data tells us:
  – Time-stamped locations of each animal per day and their activity at that time
  – Terrain information (e.g. elevation)
  – Vegetation information
  – Road map information
  – Settlements in vicinity
  – And more
Inferring Behavior Models

• Animal Behavior Models
  – Statistical model
  – For each animal A, and each hour window (e.g. 9-10am), animal will be in cell X of the park with probability $P_X$ and follow a certain trajectory with probability $P_t$.

• Poacher Behavior Model
  – Where will the poacher try to attack?
  – Historical data based on locations of snares.
  – Independent variables include proximity to road, distance from ranger posts, etc.
Inference Methodology

• Animal Behavior Models
  – GPS logs are sometimes coarse.
  – We infer the missing trajectory between two faraway time points via two technical devices
    • the principle of maximum entropy and
    • Weights defined by terrain/vegetation data.

• Poacher Behavior Model
  – Captured by a mixture of spatial & temporal Gaussian models.
  – If there was an attack at time $t$ (or space $s$), there is likely to be another attack around $t$ (or near the region $s$).
APE System

• **INPUTS:**
  – All of the data mentioned earlier
  – Animal & Poacher Behavior Models [learned from the data]
  – $M$ drones, $N$ ground patrols
  – Characteristics of Drones and Patrols

• **OUTPUT:**
  – A coordinated set of flight paths for each drone and a set of ranger patrol paths for each patrol such that the maximal number of animals is protected at any given time, i.e. we maximize the expected number of protected animals.

• Definition of “protected” intuitively means that the rangers can get to the animals before the poachers can.
Current results

• **Theorem**: Problem is NP-complete.

• We develop 2 algorithms – a “local search” algorithm and a “memetic” algorithm.

• Based on initial tests, the memetic algorithm outperforms the “local search”, improving dramatically as $M,N$ increase. Statistically validated via a $t$-test. Example:
  
  – For $M=4, N=6$: $p$-value is 0.0437417
  – For $M=8, N=12$, $p$-value is $3.99618 \times 10^{-19}$
APE Screenshots

Shows Google Map image of the Olifants West Reserve along with locations of rhinos, locations of ground patrols, and drones at one point in time.

- Blue ovals show regions under drone surveillance.
- Red ovals show the zones that each ranger can protect from poachers.
• Bottom left shows percentage of animals protected.
• With 4 drones and 8 ranger patrols, we can cover over 85% of the animals.

• Red paths show planned ranger paths during a given day
Conclusion

• APE is an initial attempt to identify methods to reduce poaching, not just of rhinos and elephants, but other species as well.

• Additional work needed to:
  – Gather more data on poachers;
  – Build better models of poachers;
  – Understand how strategic disclosures of poaching strategies can shape poachers’ behaviors, helping inter-diction;
  – Test in other geographies.
V.S. Subrahmanian  
Dept. of Computer Science & UMIACS  
University of Maryland  
College Park, MD 20742.  
Tel: 301-405-6724  
Email: vs@cs.umd.edu  
Web: www.cs.umd.edu/~vs/