Predictive Analytics for Reducing Rhino Poaching

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Data

- N. Park, E. Serra, T. Snitch, V.S. Subrahmanian. APE: A Data-Driven, Behavior-Model Based Anti-Poaching Engine, under review.
- **N. Park, E. Serra, and V.S. Subrahmanian. Saving Rhinos with Predictive Analytics, *IEEE Intelligent Systems,* July/Aug 2015, accepted, to appear.**

Talk Outline

- **Motivation: Reduce Killing of Elephants, Rhinos, and other Endangered Species**
- Approach
  - Data
  - Animal Behavior Models
  - Poacher Behavior Models
  - Algorithm
- The APE System

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

Rhino Behavior Model: Features

Feature	Meaning
$DW{\downarrow}i$ $(i{=}1,2,3)$	Distance to i'th closest water source
$DR{\downarrow}i$ $(i{=}1,2,3)$	Distance to the i'th closest road
$DH{\downarrow}i$ $(i{=}1,2,3)$	Distance of the i'th closest houses/buildings
$DV{\downarrow}i$ $(i{=}1,2,3)$	Distance to the i'th closest vegetation
MAXELEV	Maximal elevation of cell
AVGELEV	Average elevation of cell
STEEPNESS	Diff between max and min elevation of cell
VISIT(c,i)	Number of rhinos who visited a cell at most *i* units away from *c*

Question for the Audience: So what are the factors that are most predictive of cells that rhinos will visit?

Rhino Behavior Models

- Rhinos (at least those in the one park that we studied) tend to visit cells based on *elevation* and *steepness.*

If cell *c* has

- Elevation > 387m and
- Steepness < 5m

then the cell will be visited by rhinos.

Support = 10%

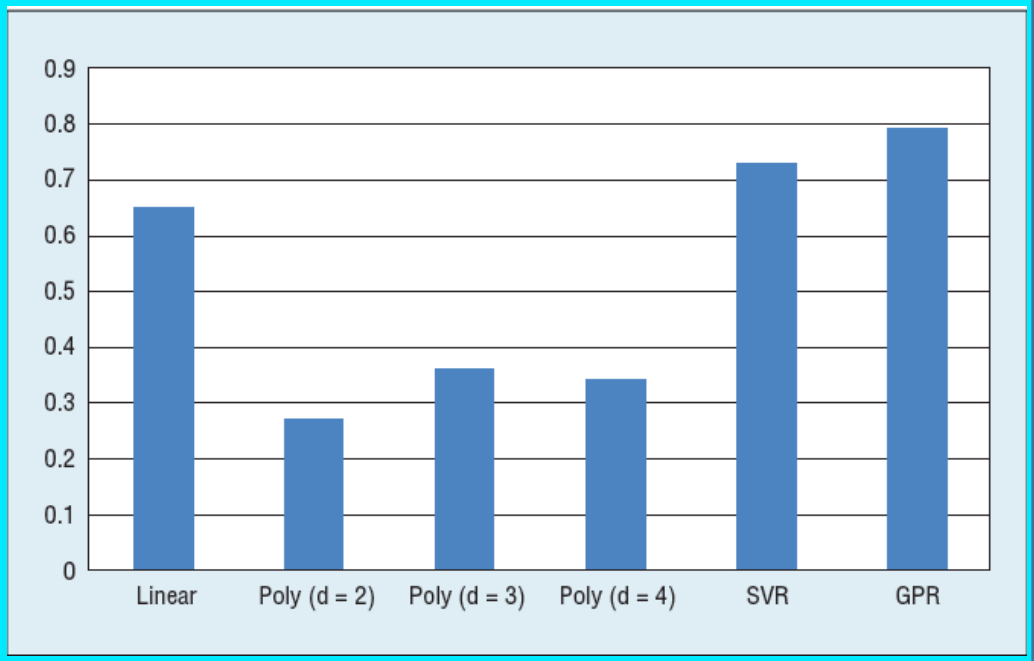
Confidence = 85%

Negative Conf = 20.25%

Lift = 3.05

Rhino Behavior Models

- Predicting the percentage of rhinos that visit a given cell.
- 80/20 10-fold cross validation.
- Multivariate regression yields a predictive accuracy of 0.79 (Pearson Correlation Coefficient)



Poacher Behavior Model: Features

Feature	Meaning
$DW{\downarrow}i$ (i=1,2,3)	Distance to i'th closest water source
$DR{\downarrow}i$ (i=1,2,3)	Distance to the i'th closest road
$DH{\downarrow}i$ (i=1,2,3)	Distance of the i'th closest houses/buildings
$DV{\downarrow}i$ (i=1,2,3)	Distance to the i'th closest vegetation
MAXELEV	Maximal elevation of cell
AVGELEV	Average elevation of cell
STEEPNESS	Diff between max and min elevation of cell
VISIT(c,i)	Number of rhinos who visited a cell at most *i* units away from *c*

Question for the Audience: So what are the factors that are most predictive of cells that poachers will target?

Poacher Behavior Model

- Poachers tend to primarily target cells that:
  - Have an elevation below 394m and
  - That have a water source in them.
- Support = 2.17%
- Confidence = 70.97%
- Negative Confidence = 4.78%
- Lift = 10.43

- Poachers tend to primarily target cells that:
  - Have an elevation below 365m and
  - There is a cell within 2 hops that have historically had at least 2 rhinos in it and
  - Distance to the nearest vegetation is less than 2 cells (i.e. 800m)
- Support = 1.08%
- Confidence = 78.57%
- Negative Confidence = 5.8%
- Lift = 11.55

Poacher Behavior Models: Multiple Behavioral Rules

Measure	Score
Accuracy	91%

Poacher Behavior Models: Multiple Behavioral Rules

Measure	Score
Accuracy	91%
True Positive Rate	67%
True Negative Rate	94%

APE System

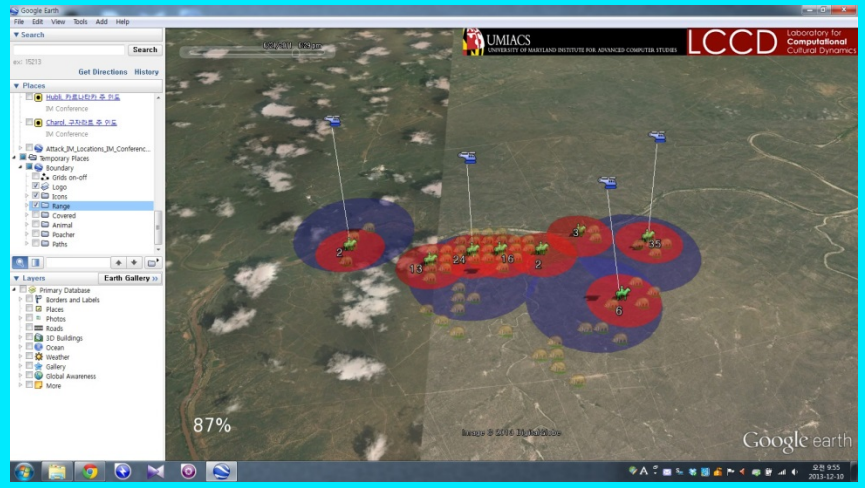
- **INPUTS**:
  - All of the data mentioned earlier
  - Animal & Poacher Behavior Models [learned from the data]
  - *M* drones, *N* ground patrols
  - Characteristics of Drones and Patrols
- **OUTPUT:**
  - A coordinated set of flight paths for each drone and a set of ranger patrol paths for each patrol 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 3.99618×10^{-19}

APE Screenshots

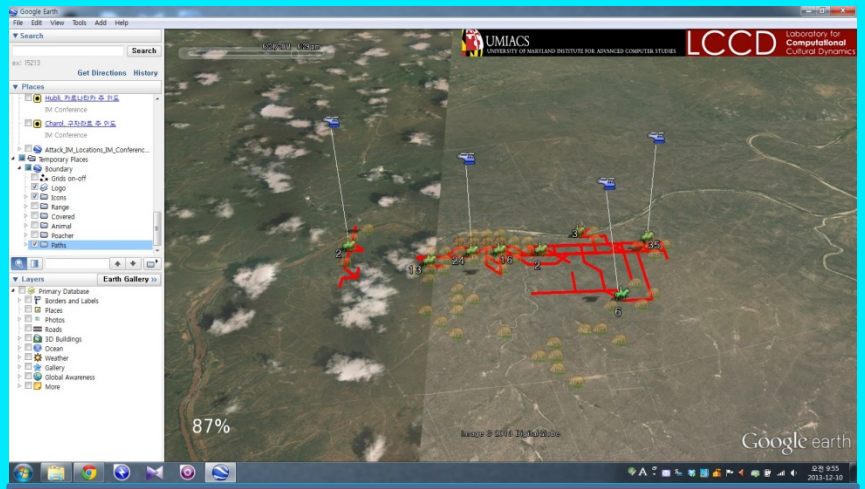
Shows Google Map image of the Olifants West Reserve along with locations of rhinos, locations of ground patrols, and drones at one point in time



- Blue ovals show regions under drone surveillance.
- Red ovals show the zones that each ranger can protect from poachers.

APE Screenshots

- 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.

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