Utilizing Remote Sensing Data to Guide the Surveillance and Control of Parasitic Diseases

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Important Helminth Diseases

- Cysticercosis
- Echinococcosis
- Foodborne trematodiases
  - Clonorchiasis
  - Fascioliasis
  - Opisthorchiasis
  - Paragonimiasis
- Lymphatic filariasis
- Schistosomiasis
- Soil-transmitted helminthiases
  - Hookworm
  - Ascarid
  - Whipworm
Leprosy new case detection rates, data reported to WHO as of January 2013

Distribution and status of preventive chemotherapy for lymphatic filariasis, worldwide, 2012

Distribution of schistosomiasis, worldwide, 2012

Status of endemicity of visceral leishmaniasis, worldwide, 2012
Impact Factors for Parasitic Diseases Infection

ENVIRONMENTAL FACTORS
- Precipitation
- Altitude
- Temperature

BIOLOGICAL FACTORS
- Breeding sites
- Insecticide resistance
- Immunity
- Age
- Health status
- Drug resistance

HUMAN RELATED FACTORS
- Malaria infection
- Longevity
- Contact human-vector
- Density
- Land use
- Livestock
- Indoor Residual Spraying
- Socioeconomic status
- Insecticide Treated Nets
- Treatment
- Migration
- Gender
- Health access
- Intermittent Preventive Treatment
Challenges on parasitic diseases surveillance and control

1. Multiple impact factors: biological, ecological, meteorically
2. Cross nations: human movement, socioeconomic situations
3. Underdeveloped health system: national wide CDC system
4. Data missing about remote regions or countryside
Utilizing remote sensing data

For all regions of interest (ROI), selecting the minimum number of targets that are prioritized to scan, which would sufficiently guarantee to cover a large percentage (or a threshold predefined according to the limitation of available resources) of all potential incidences within a period of time in the future.
Lancang-Mekong River Region (Large Scale)

- Named as Greater Mekong Subregion (GMS)
- 2.6 million square kilometers and a combined population of around 326 million.
- In 1992, Asian Development Bank (ADB) proposed a program of subregional economic cooperation,

**Problem:** how to identify epidemiological similarities in referred regions with respect to their environmental attributes
Clustering Method is defined as the process of finding a structure where the data objects are grouped into clusters which are similar behavior.

Clustering high-dimensional data

Let \( X = \{x_i\}_{i=1}^n \in \mathbb{R}^{d \times n} \) note the data set consisting of \( n \) samples (points) over \( n \)-dimensional space (attributes).

Impact factors (Input variables)
1. Environmental
2. Ecological
3. Meteorological
4. ...

Clustering algorithm (K-means)

Clustering evaluation (Silhouette function)

Separated Zones

Disease distribution

Ecozone Analysis
K-means clustering

1. Given a set of observations \((x_1, x_2, \ldots, x_n)\),
2. where each observation is a \(d\)-dimensional real vector,
3. aims to partition the \(n\) observations into \(k\) sets \((k \leq n)\) \(S = \{S_1, S_2, \ldots, S_k\}\)
4. so as to minimize the within-cluster sum of squares (WCSS):

\[
\arg \min_S \sum_{i=1}^{k} \sum_{x_j \in S_i} \|x_j - \mu_i\|^2
\]

where \(\mu_i\) is the mean of points in \(S_i\)
Remote sensing data were retrieved from Moderate Resolution Imaging Spectroradiometer (MODIS), ranging from Jan. 2010 to Jan. 2014 with temporal interval of eight days and spatial resolution of 1KM.
Mapping parasitic diseases in GMS

Helminth
- Cysticercosis/Taeniasis
- Echinococcosis
- Foodborne trematodiases
  - Clonorchiasis
  - Fascioliasis
  - Opisthorchiasis
  - Paragonimiasis
- Lymphatic filariasis
- Schistosomiasis
- Soil-transmitted helminthiases (STH)
SPOT5 images covering the whole study area and acquired on March 16, 2006 were obtained from the China Remote Sensing Satellite Ground Station (Beijing, China). This imagery has a spatial resolution of 2.5m in panchromatic mode and 10 m in colored mode.
Snail habitats prediction (Middle Scale)

*Flooding season in 1983 Normal water level in 1984*

Three cloud-free Landsat-5 TM images of the study area with a spatial resolution of 30m
Three cloud-free Landsat-5 TM images of the study area with a spatial resolution of 30m.

Result: snail habitats prediction
Next steps

1. **Extension and improvement** of existing approaches through the front fields epidemiological practice

2. **Small scale** local environment analysis to investigate the transmission mechanism of parasitic diseases

3. **Large scale** regional analysis to evaluate the risks of environmental changes, including climate and land usage.
Conclusions

1. Parasitic diseases and environmental factors
2. Challenges in diseases surveillance and control
3. Active surveillance planning
4. Two case studies by exploring remote sensing data

Thank you!