Game Bot Identification based on Manifold Learning

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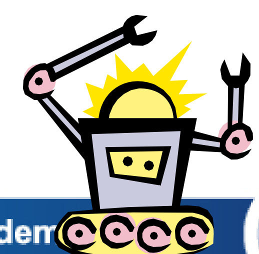


Game Bots

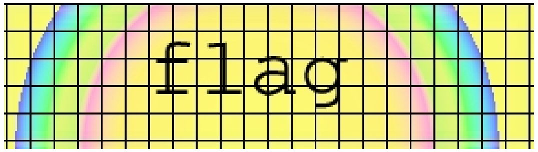
- Game bots: automated AI programs that can perform certain tasks in place of gamers
- Popular in MMORPG and FPS games
  - MMORPGs (Role Playing Games)
    accumulate rewards in 24 hours a day
    ➔ break the balance of power and economies in game
  - FPS games (First-Person Shooting Games)
    a) improve aiming accuracy only
    b) fully automated
    ➔ achieve high ranking without proficient skills and efforts

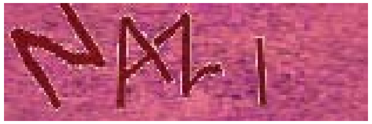
Bot Detection

- Detecting whether a character is controlled by a bot is difficult since a bot obeys the game rules perfectly
- No general detection methods are available today
- State of practice is identifying via human intelligence
  - Detect by “bots may show regular patterns or peculiar behavior”
  - Confirm by “bots cannot talk like humans”
  - Labor-intensive and may annoy innocent players

Related Work

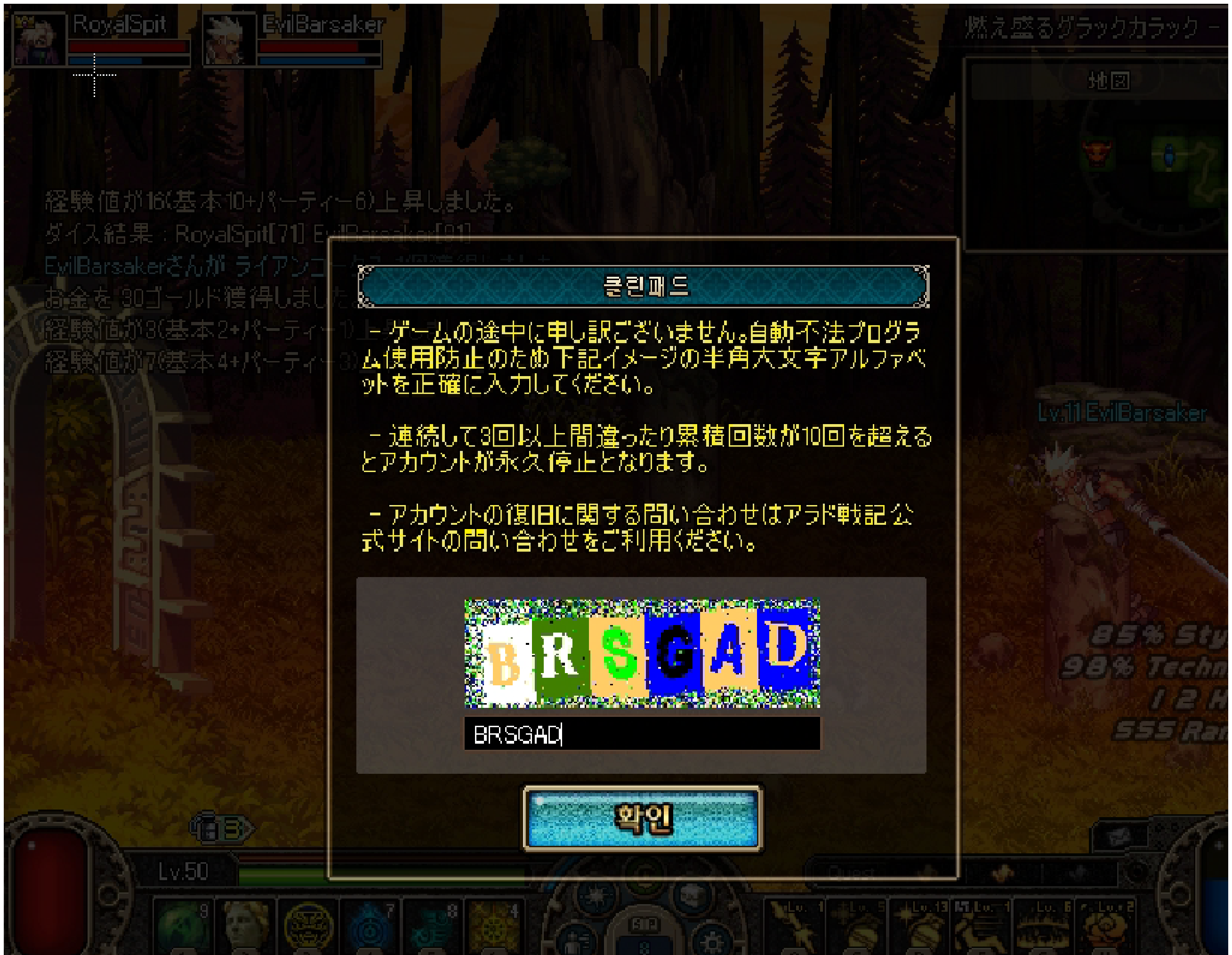
- Prevention
  - CAPTCHA (reverse Turing tests) [Golle et al; 2005]





- Detection
  - Process monitoring at client side [GameGuard]
    - Bot program’s signatures are keeping changing
  - Traffic analysis at the network [Chen et al; 2006]
    - Remove bot traffic’s regularity by heavy-tailed random delays
  - Aiming bot detection using DBN [Yeung et al; 2006]
    - Specific to aiming bots that help aim the target accurately

CAPTCHA in a Japanese Online Game



Our Goal of Bot Detection Solutions

- Passive detection
  ➔ No intrusion in players' gaming experience

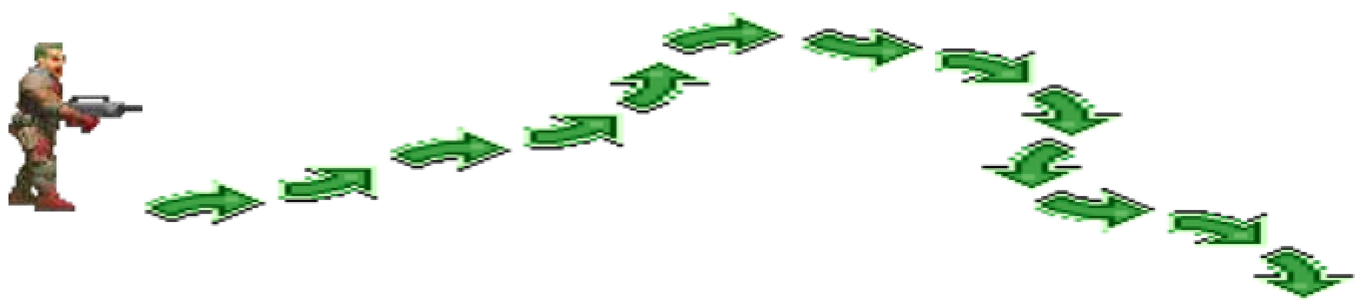
- No client software support is required

- Generalizable schemes (for other games and other game genres)

Our Solution: Trajectory + Manifold Learning

- Based on the avatar’s movement trajectory in game
- Applicable for all genres of games where players control the avatar’s movement directly
- Avatar’s trajectory is high-dimensional (both in time and spatial domain)

  ➔ Use manifold learning to distinguish the trajectories of human players and game bots



The Rationale behind Our Scheme

- The trajectory of the avatar controlled by a human player is hard to simulate for two reasons:
  - Complex context information:
    Players control the movement of avatars based on their knowledge, experience, intuition, and a great deal of environmental information in game.
  - Human behavior is not always logical and optimal
- How to model and simulate realistic movements (for game agents) is still an open question in the AI field.

Bot Detection: A Decision Problem

Q: Whether a bot is controlling a game client given the movement trajectory of the avatar?

A: Yes / No?

Talk Progress

- Overview

- Data Description
- Proposed Scheme
  - Pace vector construction
  - Dimension Reduction using Isomap
  - Classification
- Performance Evaluation
- Conclusion

Case Study: Quake 2

- Choose Quake 2 as our case study
  - A classic FPS game
  - Many real-life human traces are available on the Internet
    ➔ more realistic than traces collected in experiments

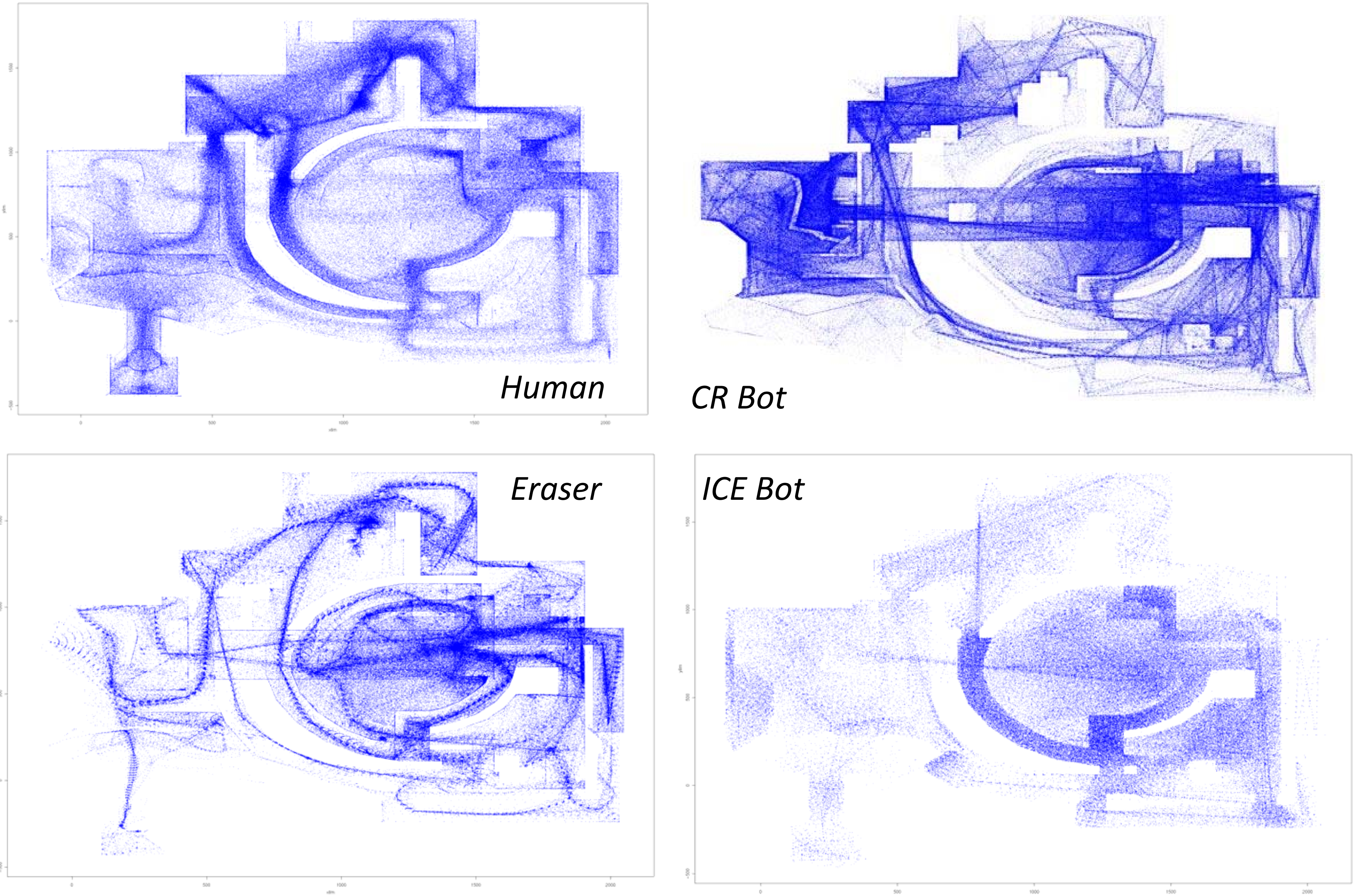
A Screen Shot of Quake 2

Data Collection

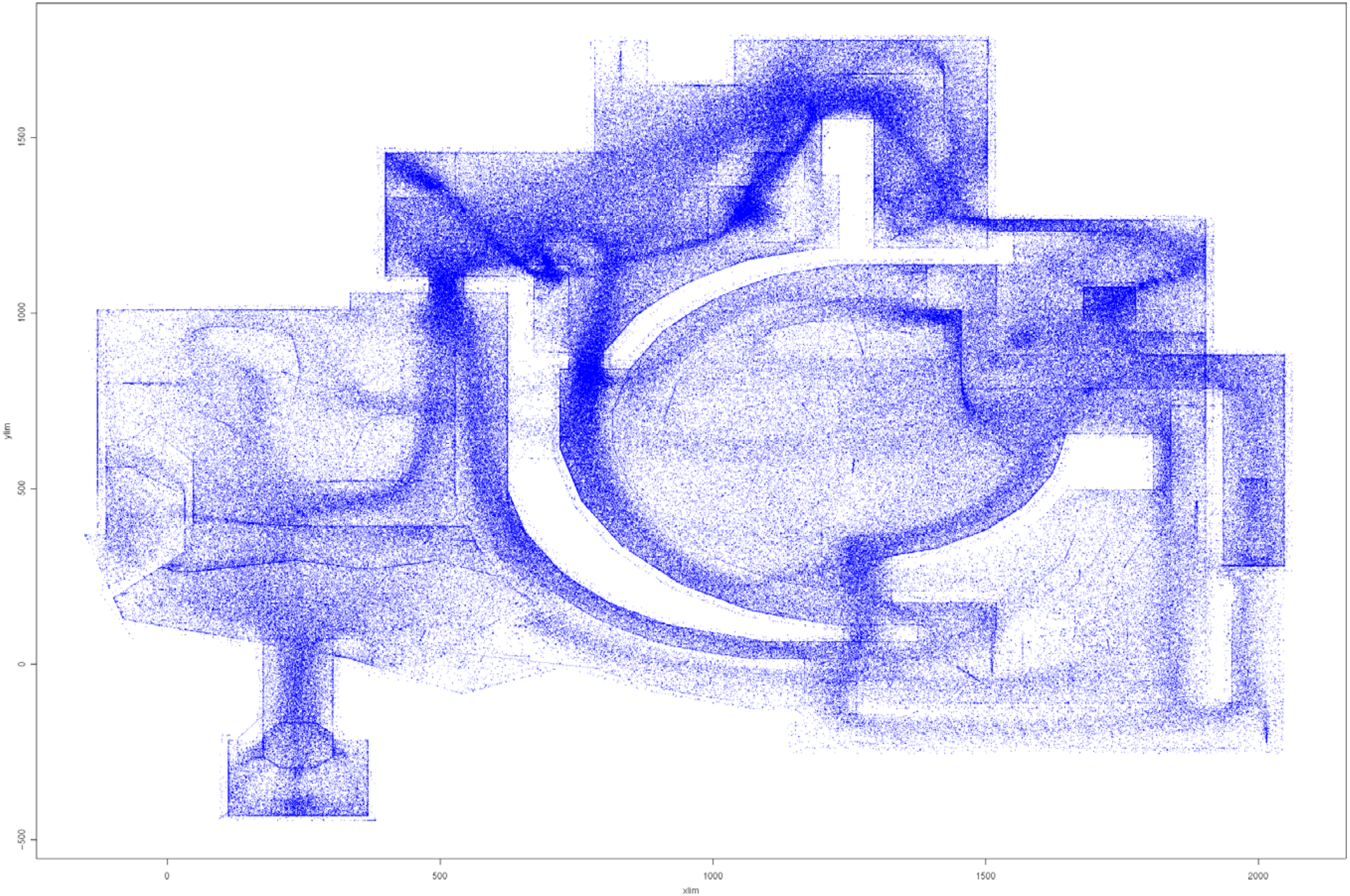
- Human traces downloaded from fan sites including GotFrag Quake, Planet Quake, Demo Squad, and Revilla Quake Site
- Bot traces collected on our own Quake server
  - CR BOT 1.14
  - Eraser Bot 1.01
  - ICE Bot 1.0
- Totally 143.8 hours of traces were collected

Name	Number	Trace Length	Total	Active
Human	282	1000 seconds	78.0 hours	89%
CR	75	1000 seconds	20.8 hours	89%
Eraser	102	1000 seconds	28.3 hours	92%
ICE	60	1000 seconds	16.7 hours	67%

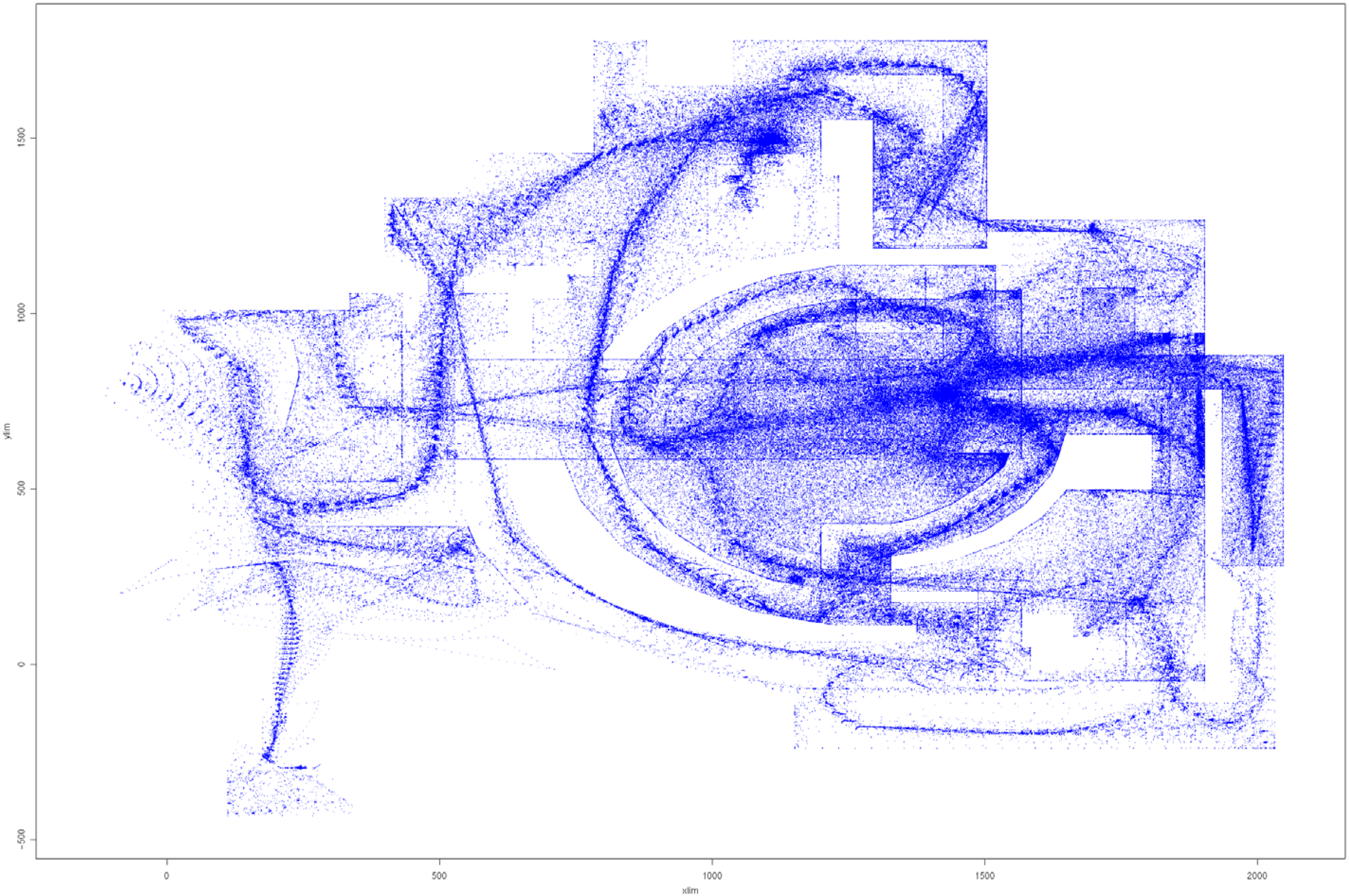
Aggregate View of Trails (Human & 3 Bots)



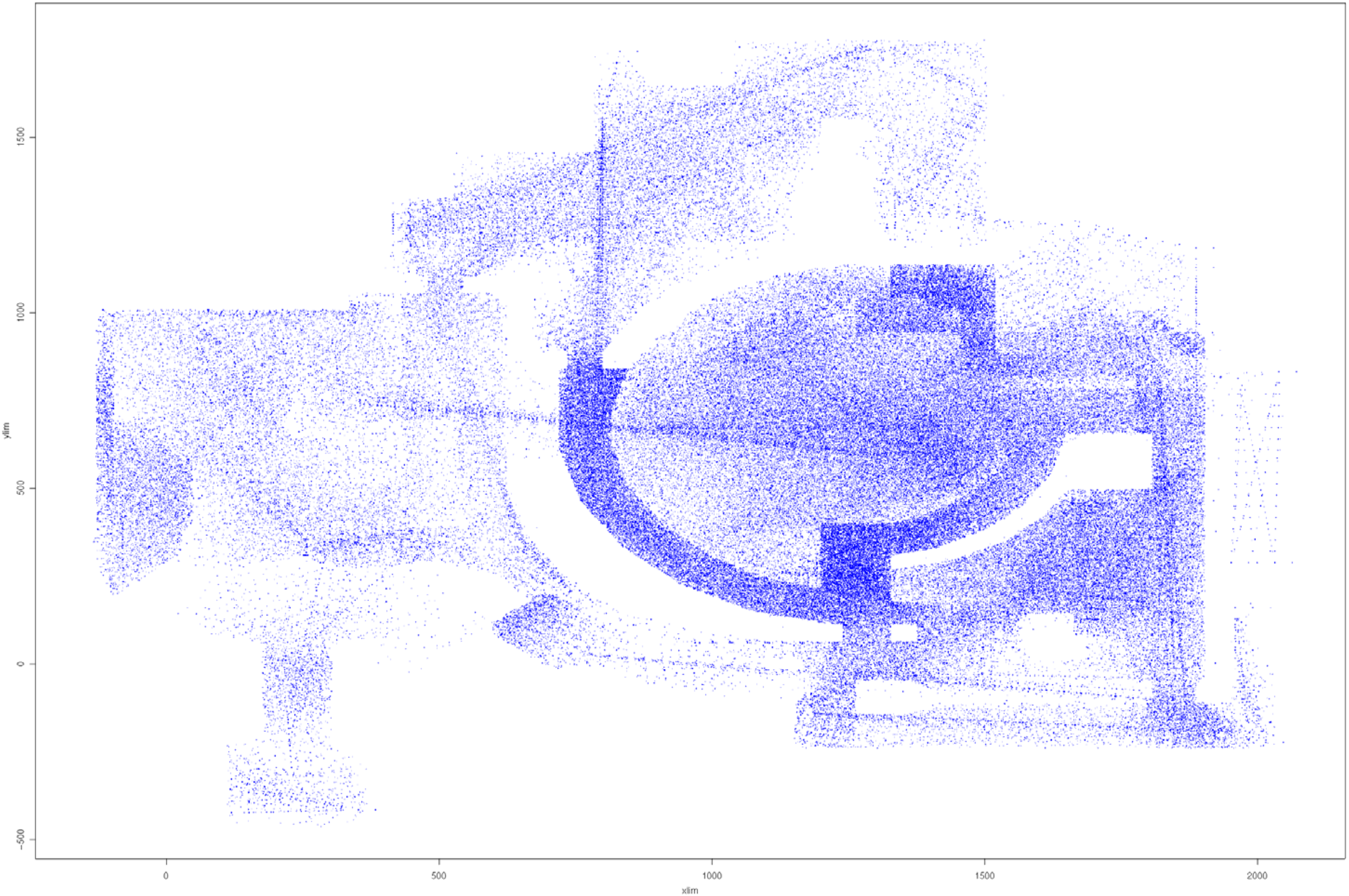
Trails of Human Players



Trails of Eraser Bot



Trails of ICE Bot



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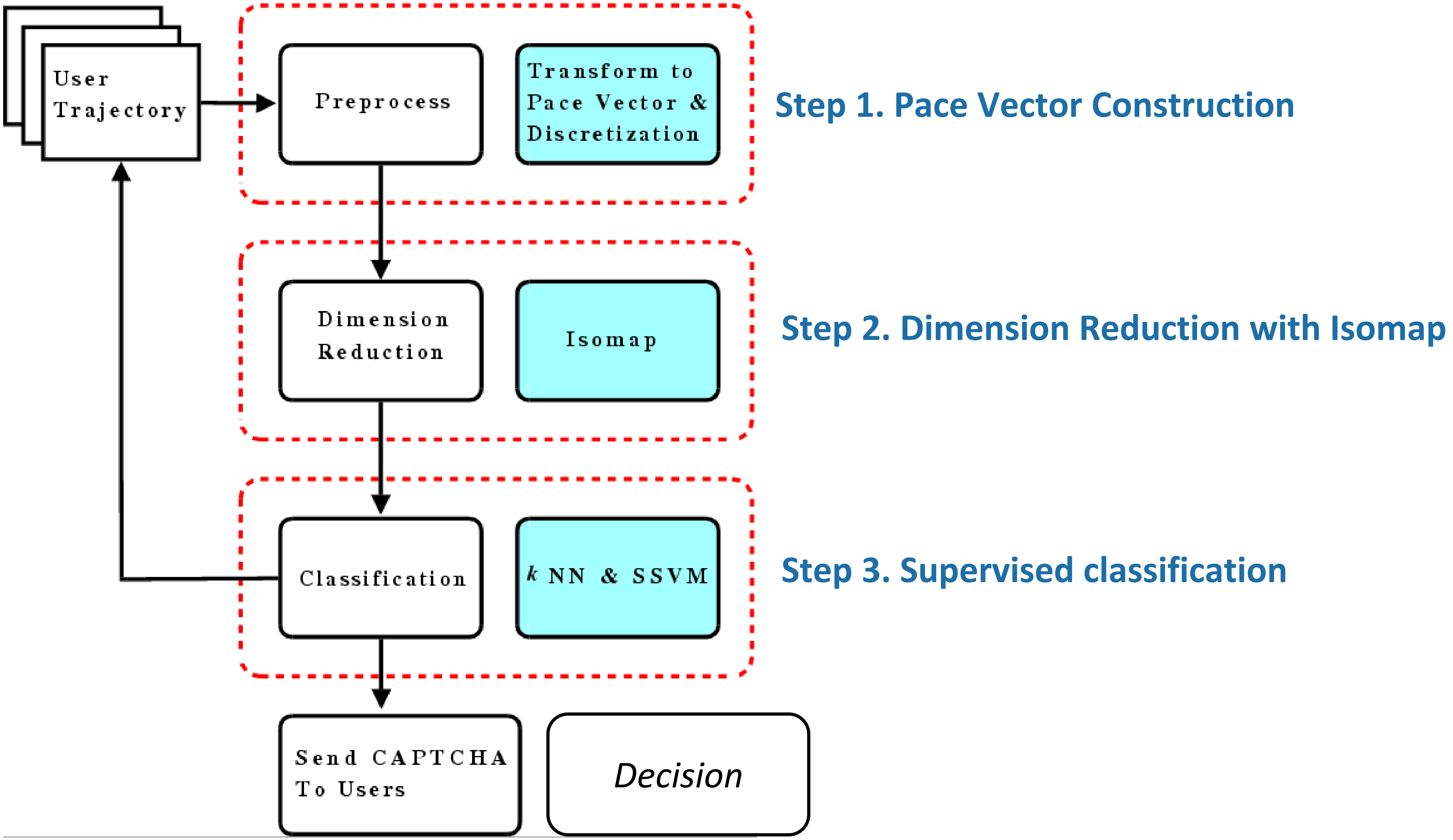
The Complete Process: Overview



Step 1. Pace Vector Construction

- For each trace s_n , we compute the pace (distance) in successive two seconds by

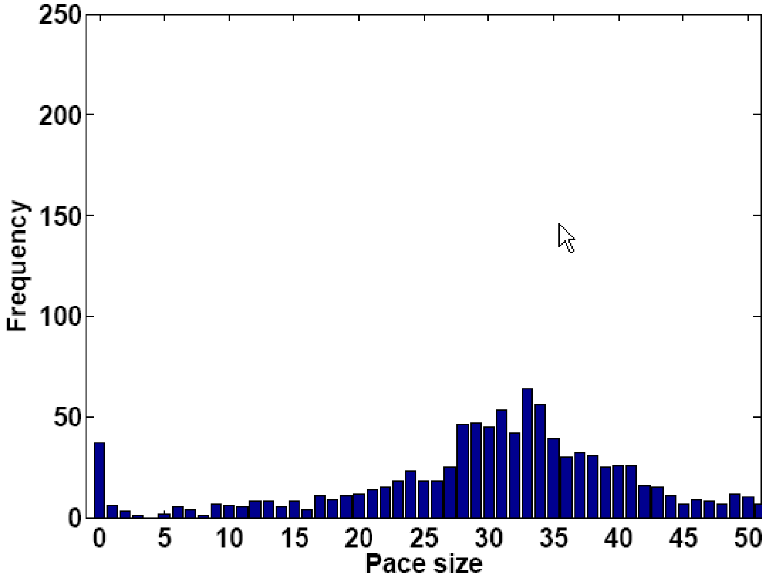
$$\|\mathbf{s}_{n,i+1} - \mathbf{s}_{n,i}\| = \sqrt{(\mathbf{s}_{n,i+1} - \mathbf{s}_{n,i})^T(\mathbf{s}_{n,i+1} - \mathbf{s}_{n,i})}$$

- We then compute the distribution (histogram) of paces with a fixed bin size by

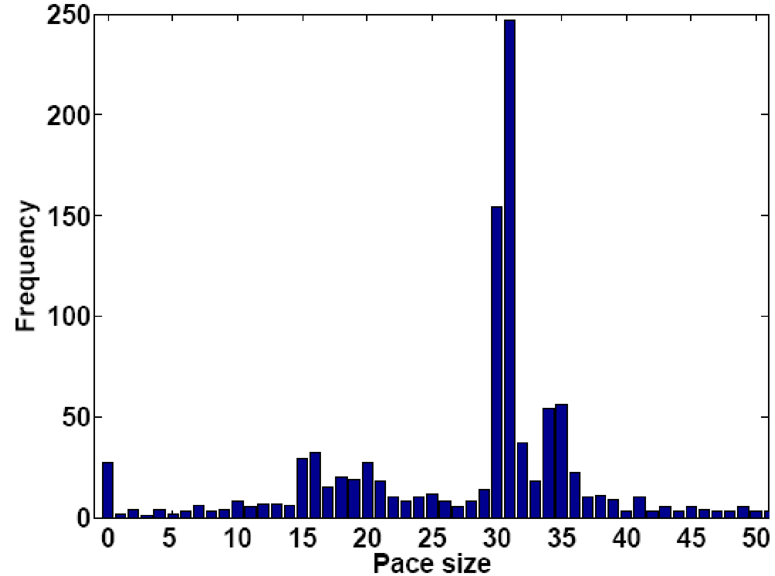
$$\mathbf{F}_n = (f_{n,1}, f_{n,2}, \ldots, f_{n,B})$$

where B is the number of bins in the distribution.

Pace Vector: An Example



(A) Human



(B) Bot

B is set to 200 (dimensions) in this work

Step 2. Dimension Reduction with Isomap

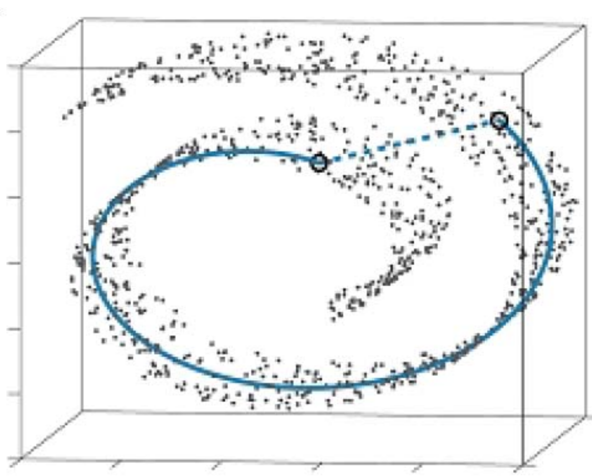
- We adopt Isomap for nonlinear dimension reduction for
  - Better classifiaction accuracy
  - Lower computation overhead in classification

- Isomap
  - Assume data points lie on a manifold

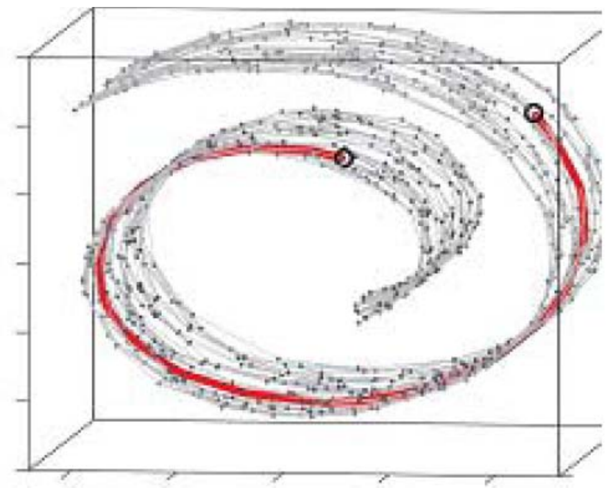
    A mathematical space in which every point has a neighborhood which resembles Euclidean space, but in which the global structure may be more complicated. (Wikipedia)

  - 1. Construct the neighborhood graph by kNN (k-nearest neighbor)
  - 2. Compute the shortest geodesic path for each pair of points
  - 3. Reconstruct data by MDS (multidimensional scaling)

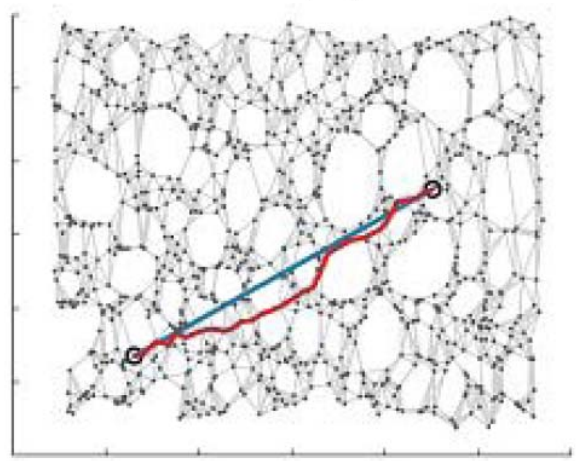
A Graphic Representation of Isomap



(A) A Swiss Roll Data

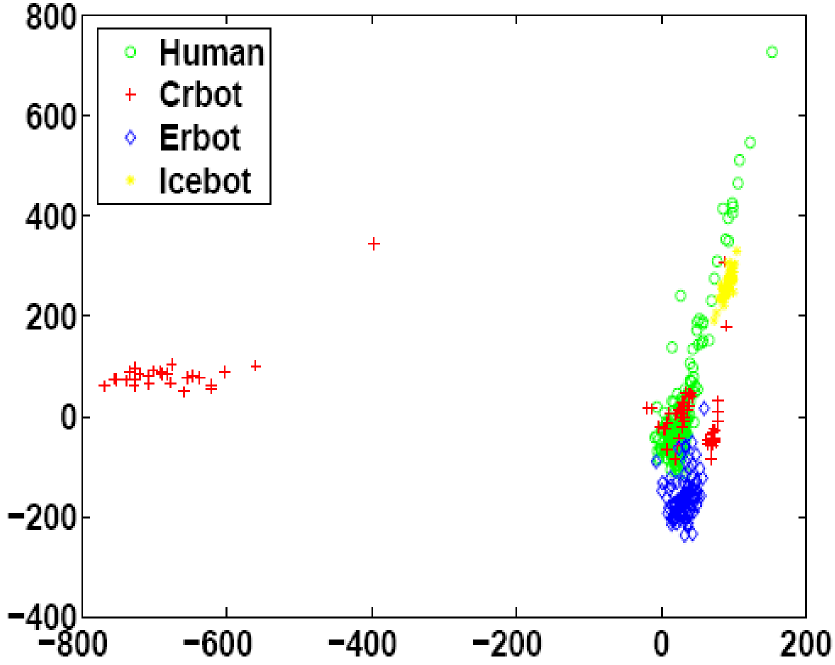


(B) Neighborhood Graph

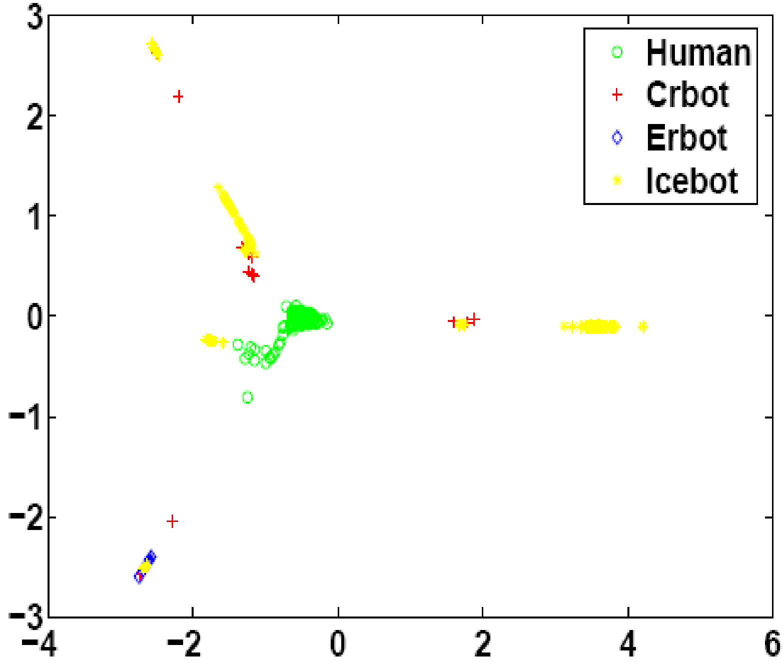


(C) After Mapping by Isomap

PCA (Linear) vs. Isomap (Nonlinear)



(A) PCA



(B) Isomap

Step 3. Classification

- Apply a supervised classifier on the Isomap-reduced pace vectors
  - SVM (Support Vector Machine) in our study
- To decide whether a trajectory belongs to a game bot or a human player

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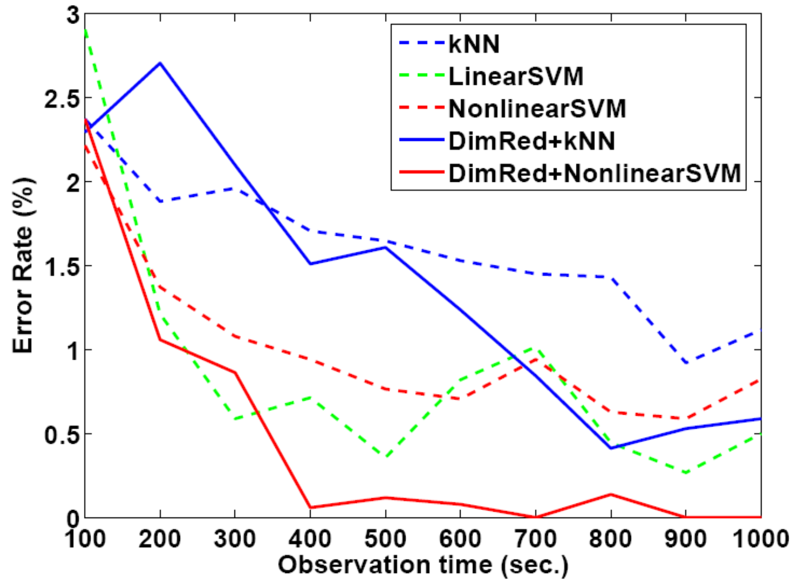
Five Methods for Comparison

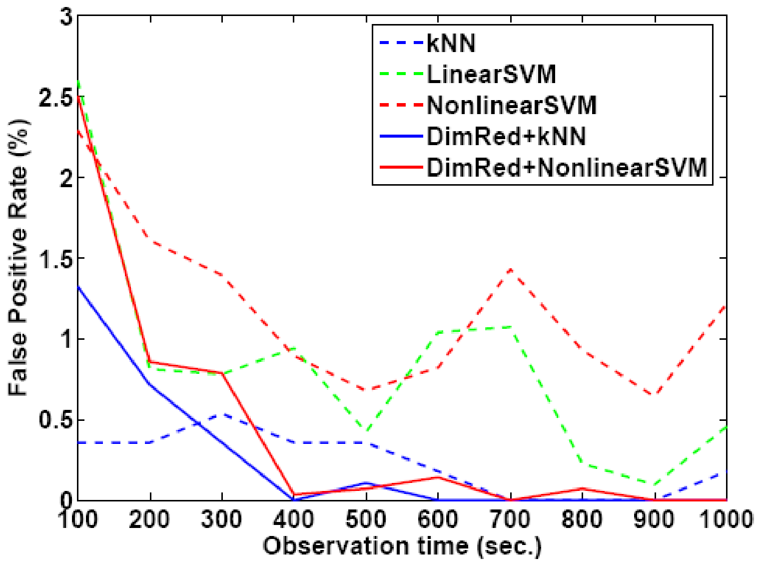
<table>
<tr><th>Method</th><th>Data Input</th></tr>
<tr><td>kNN</td><td rowspan="3">Original 200-dimension Pace Vectors</td></tr>
<tr><td>Linear SVM</td></tr>
<tr><td>Nonlinear SVM</td></tr>
<tr><td>Isomap + kNN</td><td rowspan="2">Isomap-reduced Pace Vectors</td></tr>
<tr><td>Isomap + Nonlinear SVM</td></tr>
</table>

Evaluation Results

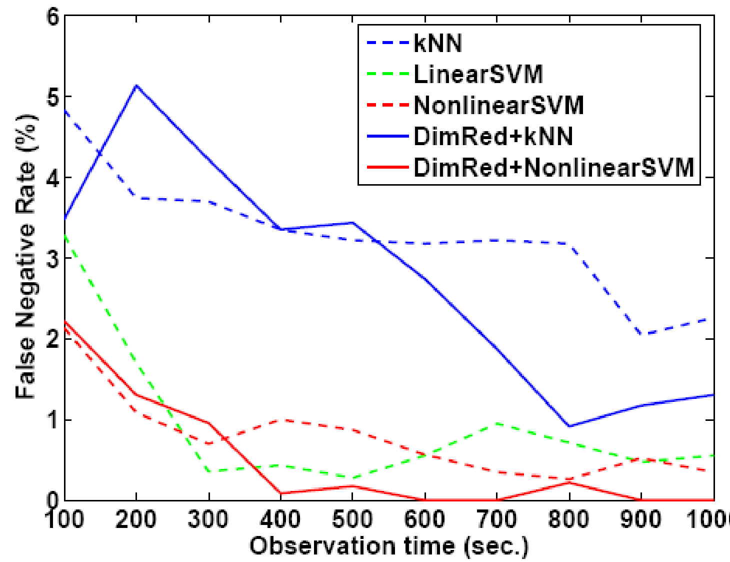


Error Rate

False Postive Rate



False Negative Rate

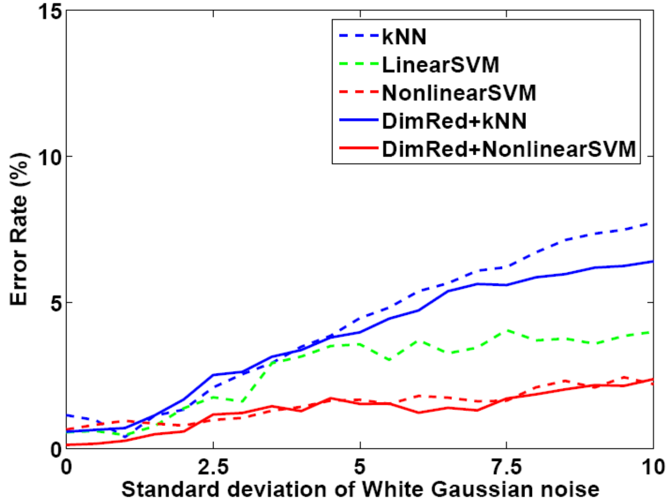


Addition of Gaussian Noise

- Bot programmers can try to evade from detection by adding random noise into bots’ movement behavior

- Evaluate the robustness of our schemem by adding Gaussian noise into bots’ trajectories

Evaluation Results



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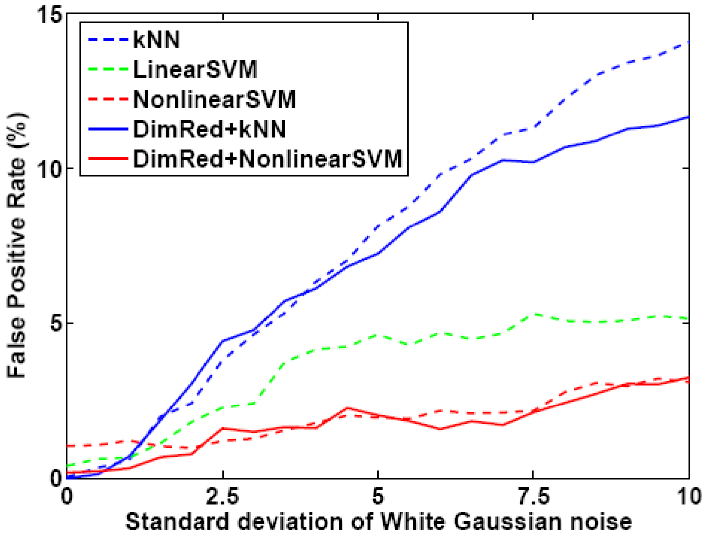

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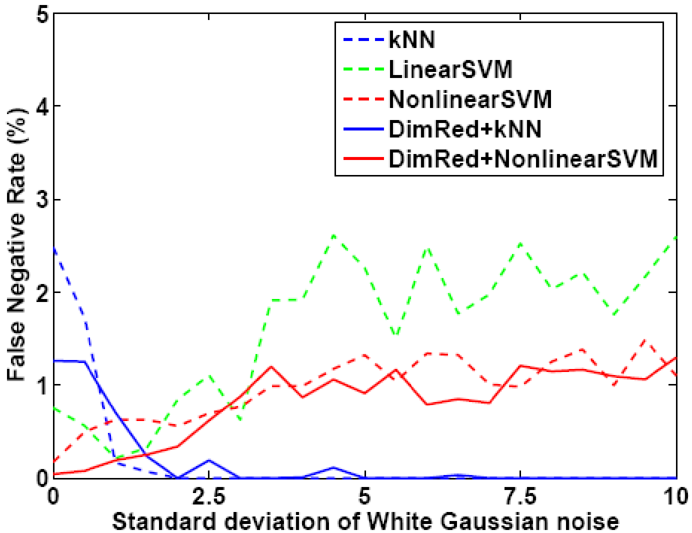
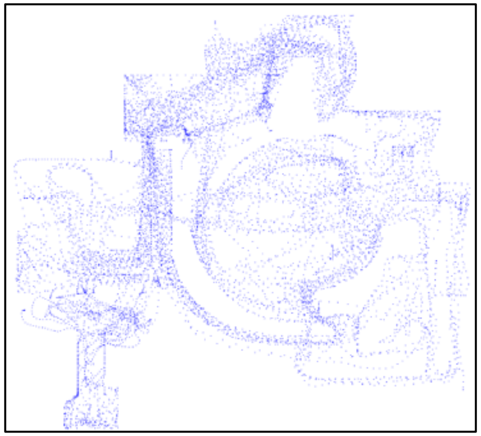


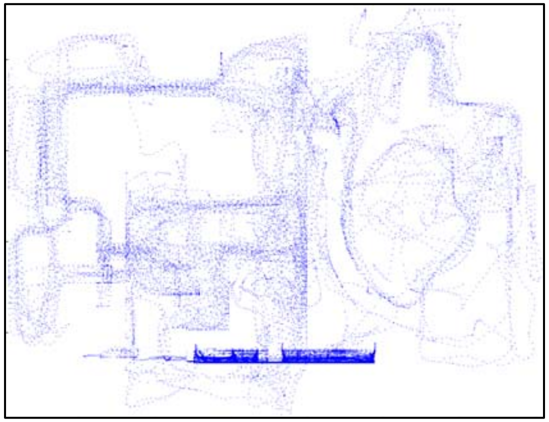
Cross-Map Validation

- Human movement may be restricted by the environment around him/her
- Whether a classifier trained for a map can be used for detecting bots on another map?

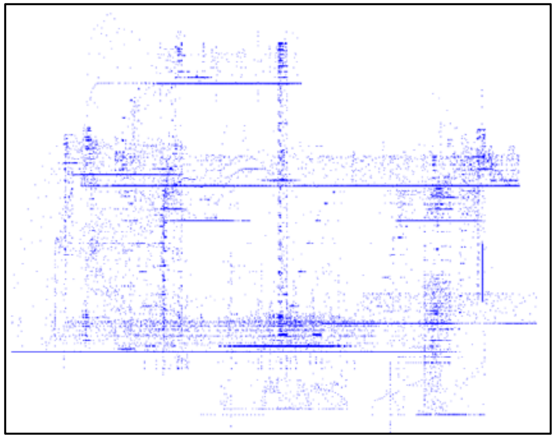
The Edge



The Frag Pipe



Warehouse



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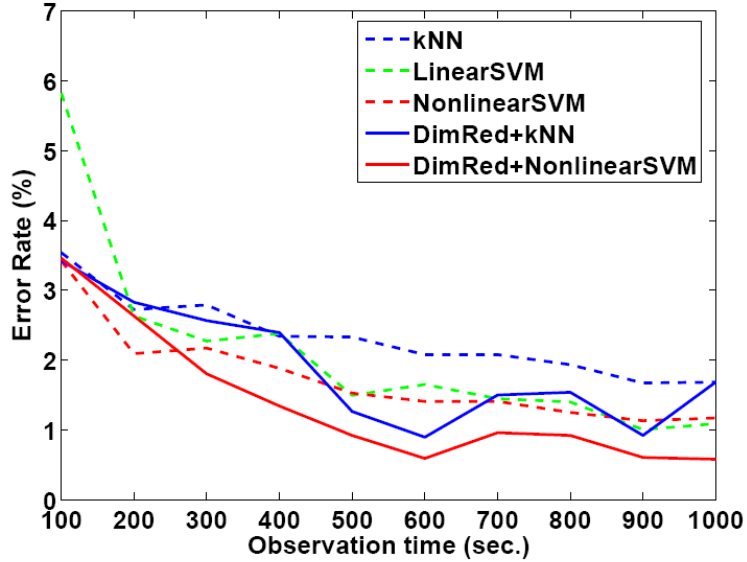

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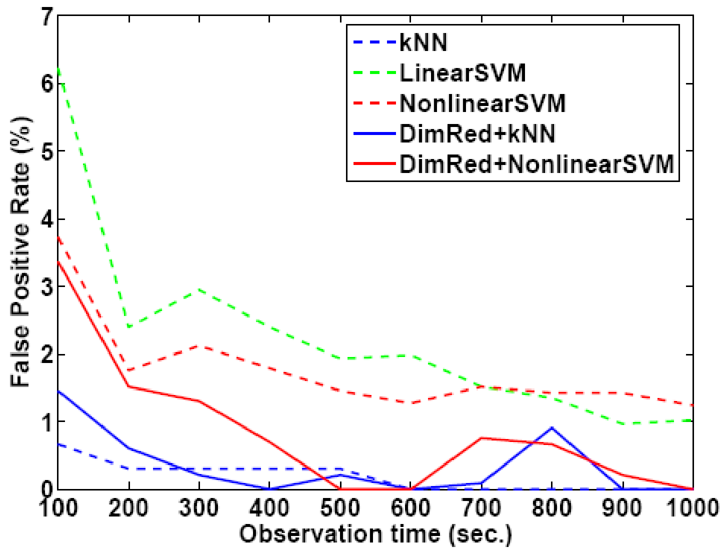

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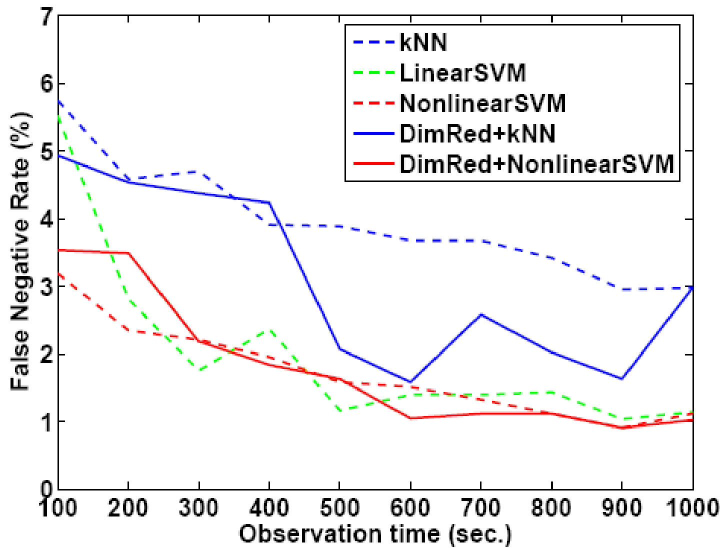

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Conclusion

- We propose a trajectory-based approach for detecting game bots.
- The results show that the Isomap + nonlinear SVM approach performs good and stable results.
- Human's logic in controlling avatars is hard to simulate ➔ we believe this approach has the potential to be a general yet robust bot detection methodology

Future Work

- Include more spatial-domain information in the pace vector
- Validate our methodology on other games (game genres)

Thank You!

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http://www.iis.sinica.edu.tw/~ktchen