Kaggle Project

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Overview

Problem Definition1111

- information security
- Group Outlying Aspects Mining

Related Work and Challenges

- Related Work - Outlying Aspects Mining
- Challenges (1)

GOAM Algorithm

- Step One - Group Feature Extraction
- Step Two - Outlying Degree Scoring
- Step Three - Outlying Aspects Identification

Evaluation Results

- Synthetic Dataset
- NBA Dataset

Conclusion

Problem Definition1111

information security

Defn

Outlying Aspects Mining aims to identify the outstanding features of the query object1111.

- A teacher may be interested in the characteristics that make one student distinctive from others.
- NBA coaches would prefer to find out the strengths and weaknesses of the player (a query object).

Player	3PT%	FTA	FT%	To
P_1	65	4	33	8
P_2	78	1	65	5
P_3	58	6	46	3
P_4	68	1.2	85	6.2
P_5	58	6.2	36	3.4

Outlying Aspects Mining vs Outlier Detection

Player	3PT%	FTA	FT%	To
P_1	65	4	33	8
P_2	78	1	65	5
P_3	58	6	46	3
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P_5	58	6.2	36	3.4

Outlying Aspects Mining

- Explain the distinctive aspects of the query object.
- The query object may (or may not) be an outlier.

Outlier Detection

- Find out all unusual objects in the whole dataset.
- No explanation on how they are different.

Group Outlying Aspects Mining

Defn

Group outlying aspects mining aims to identify the outstanding features of the group of query object.

- Doctors desire to identify the merits & demerits between a group of cancer patients and normal people.
- NBA coaches are passionate about exploring the obvious advantages & disadvantages of the team.

Figure 1: Medical

Figure 2: NBA-Team

Problem Formalization

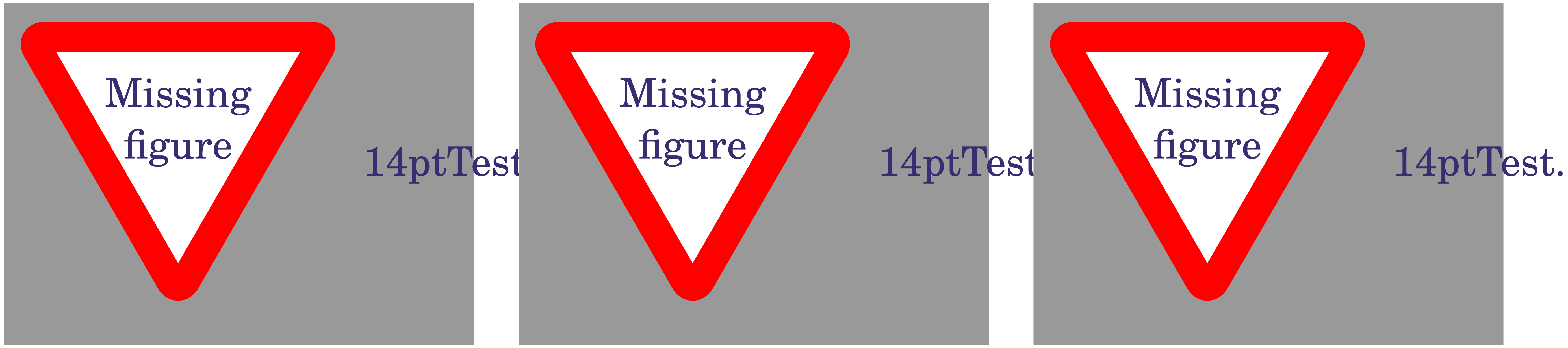
Defn

Group outlying aspects mining aims to identify the top-k group outlying subspace $s \subseteq F$ in which the query group G_q is distinctive with other groups.

- $G = \{G_q, G_2, G_3, \ldots, G_n\}$ ⇔ a set of groups.
- G_q ⇔ the query group.
- Other groups ⇔ comparison groups.
- Each object in the group has d features $F = \{f_1, f_2, \ldots, f_d\}$.

Term Definition

- Top-k group outlying subspaces
  - $\rho_s(\cdot) \Rightarrow$ outlying scoring function.
  - $\rho_s(\cdot)$ quantifies the outlying degree of the query group G_q in the subspace s.
  - Order by DESC using scoring function $\rho(\cdot)$ to identify top K group outlying subspaces.



(a) Original Feature Spaces

(b) Group Outlying Spaces

(c) Another Subspaces

Term Definition

- Trivial Outlying Features
  - One-dimension subspaces.
  - G_q's outlying degree $\rho(\cdot) > \alpha$.

Table 1: $\alpha = 4$

Feature	Outlying Degree
$\{F_1\}$	4.351
$\{F_3, F_4\}$	4.024
$\{F_2, F_4\}$	2.318
$\{F_2\}$	2.002
$\{F_3\}$	1.028

Term Definition

- Non-Trivial Outlying Subspaces
  - Multi-dimension subspaces.
  - G_q's outlying degree $\rho(\cdot) > \alpha$.

Table 2: $\alpha = 4$

Feature	Outlying Degree
$\{F_1\}$	4.351
$\{F_3, F_4\}$	4.024
$\{F_2, F_4\}$	2.318
$\{F_2\}$	2.002
$\{F_3\}$	1.028

Problem Definition1111

Related Work and Challenges

Related Work - Outlying Aspects Mining

Challenges (1)

GOAM Algorithm

Evaluation Results

Conclusion

Related Work and Challenges

Related Work - Outlying Aspects Mining

Problem Definition1111

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- Existing Methods - Feature selection
  - To distinguish two classes: the query point (positive) & rest of data (negative)

Disadvantages

- Positive and negative classes are Not balanced.
- Not quantify the outlying degree accurately.
- Not identify group outlying aspects.

Advantages

- Easy to operate.
- Resolve dimensionality bias.

Related Work - Outlying Aspects Mining

- Existing Methods - Score-and-search
  - Define an outlying score function.
  - Search subspaces.

Disadvantages

- Dimensionality bias.
- Search efficiency is Not high (dataset is large).
- Not identify group outlying aspects.

Advantages

- Quantify the outlying degree correctly.
- High Comprehensibility.

Problem Definition1111

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Group Outlying Aspects Mining

- Focus on differences between groups.
- Multiple points.

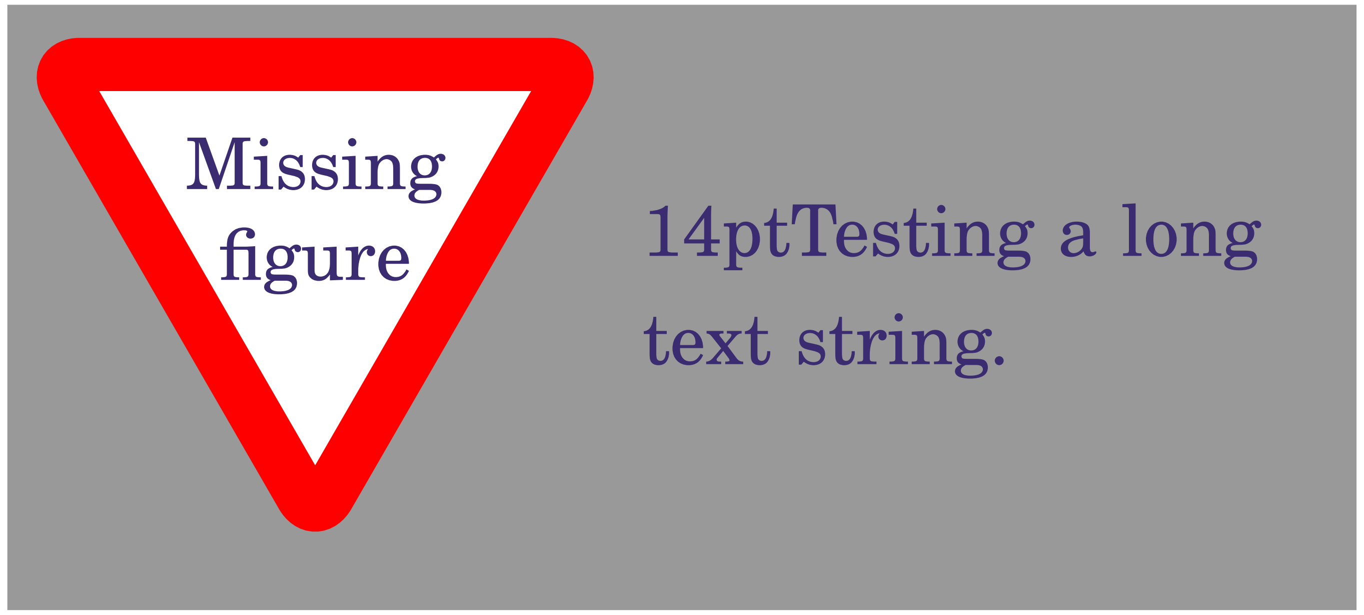


Figure 3: Group Outlying Aspects Target

Outlying Aspects Mining

- Concentrates on differences between objects.
- One point.

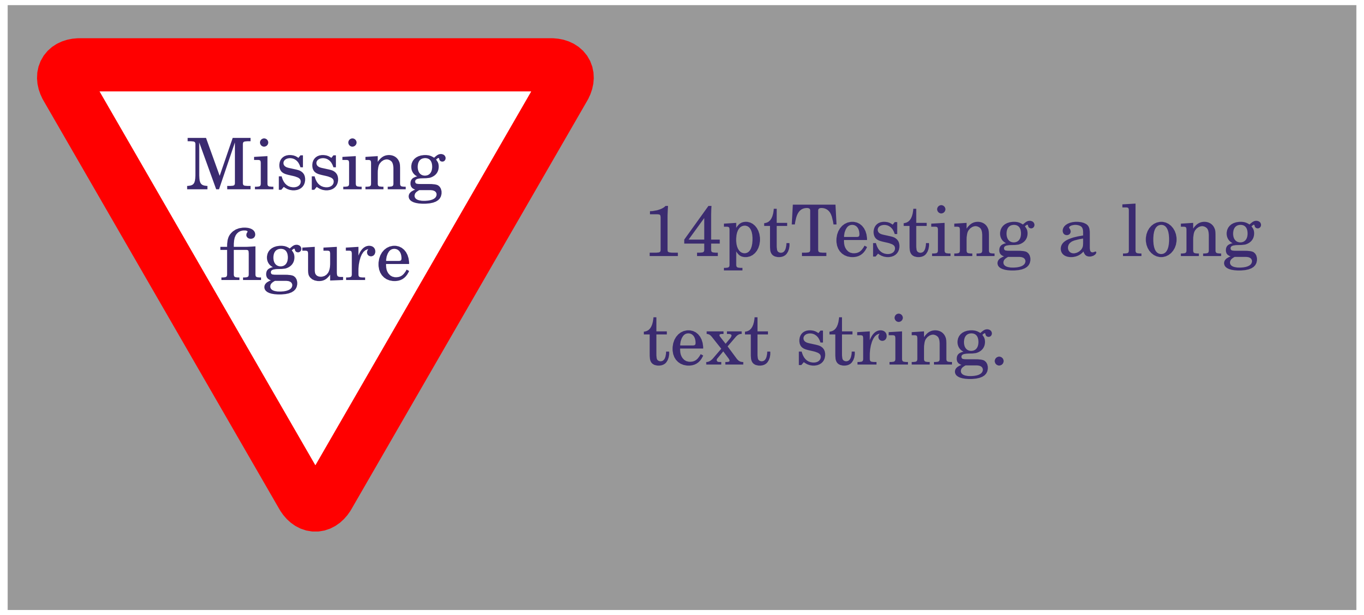


Figure 4: Outlying Aspects Target

Challenges (1)

- How to represent the group features.
  - Can be affected by outlier values.
  - Can Not reflect the overall distribution of group features.

Challenges (2)

- How to evaluate the outlying degree in different aspects.
  - Need design a scoring function when necessary.
  - Adopting an appropriate scoring function (without dimension bias) remains a problem.

Challenges (3)

- How to improve the efficiency.
  - When the dimension of the data is high, the candidate subspace grows exponentially.
  - It will easily go beyond the limits of the computation resources.

GOAM Algorithm

Framework of GOAM algorithm:

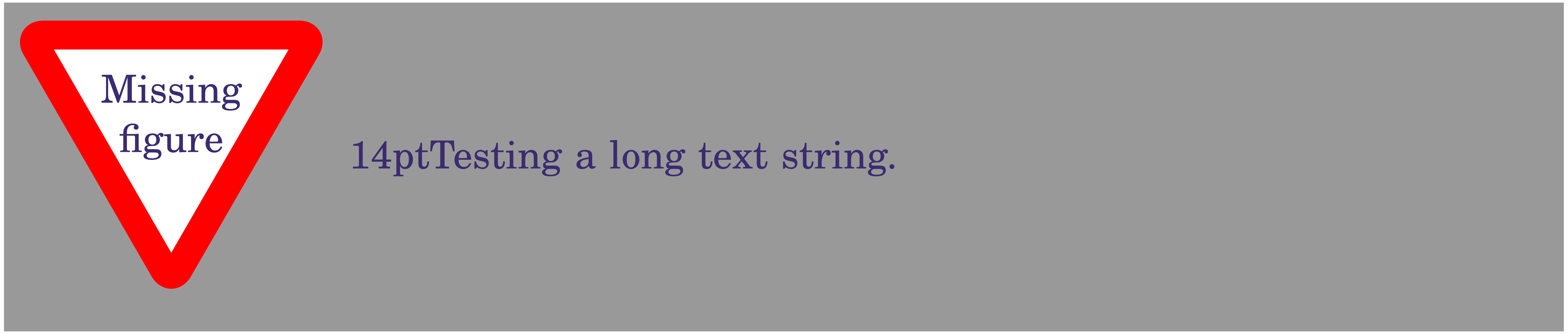


Figure 5: Framework of GOAM Algorithm

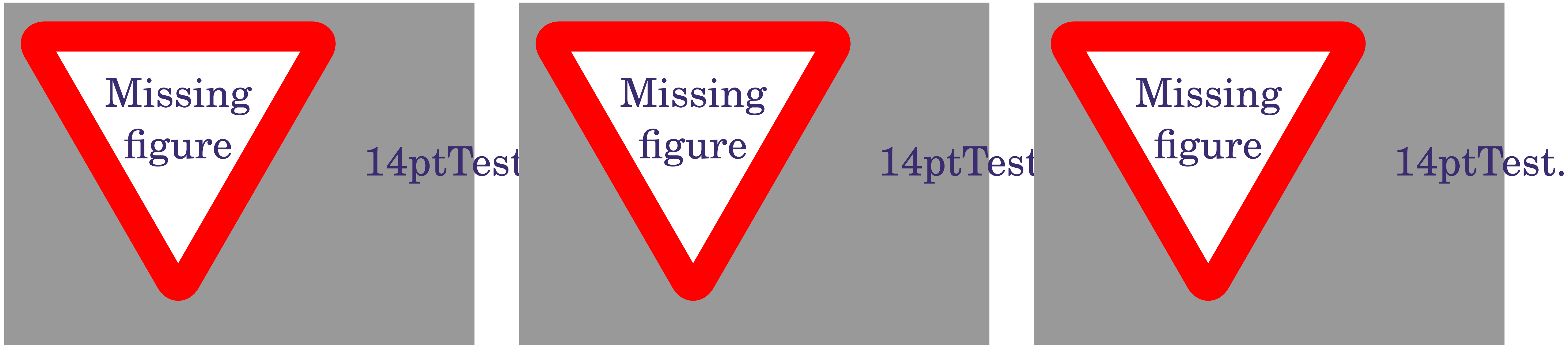
Step One - Group Feature Extraction

- Suppose f_1, f_2, f_3 are three features of G_q.

f_1: $\{x_1, x_2, x_3, x_4, x_5, x_2, x_3, x_4, x_1, x_2\}$

f_2: $\{y_2, y_2, y_1, y_2, y_3, y_3, y_5, y_4, y_4, y_2\}$

f_3: $\{z_1, z_4, z_2, z_4, z_5, z_3, z_1, z_2, z_4, z_2\}$

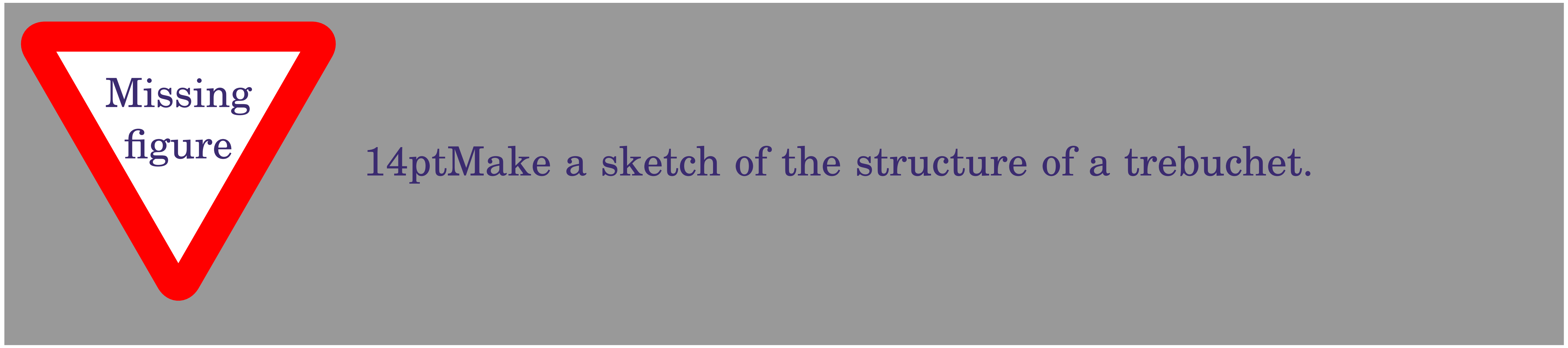


(a) f_1 (b) f_2 (c) f_3

Figure 6: Histogram of G_q on three features

Step Two - Outlying Degree Scoring

- Calculate Earth Mover Distance
  - Represent one feature among different groups
  - Purpose: calculate the minimum mean distance



14ptMake a sketch of the structure of a trebuchet.

Figure 7: EMD of one feature

Step Two - Outlying Degree Scoring

- Calculate the outlying degree

$$OD(G_q) = \sum_1^n EDM(h_{q_s}, h_{k_s})$$

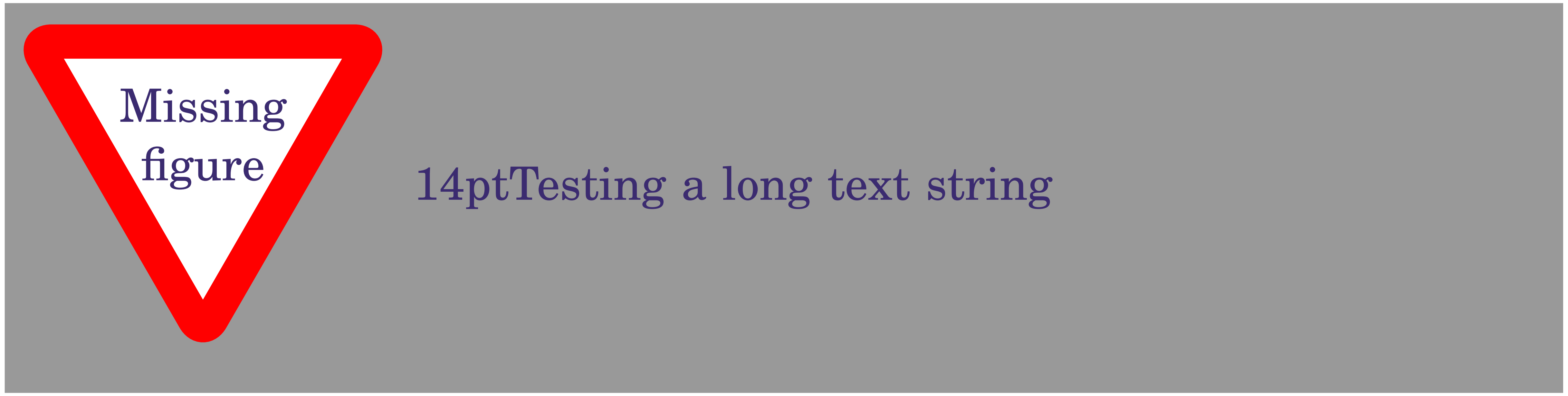
  - n ⇔ the number of contrast groups.
  - h_{k_s} ⇔ the histogram representation of G_k in the subspace s.

Step Three - Outlying Aspects Identification

- Identify group outlying aspects mining based on the value of outlying degree.
- The greater the outlying degree is, the more likely it is group outlying aspect.

Pseudo code

- Pseudo code of GOAM algorithm



Illustration

Table 3: Original Dataset

G_1	F_1	F_2	F_3	F_4	G_2	F_1	F_2	F_3	F_4
	10	8	9	8		7	7	6	6
	9	9	7	9		8	9	9	8
	8	10	8	8		6	7	8	9
	8	8	6	7		7	7	7	8
	9	9	9	8		8	6	6	7
G_3	F_1	F_2	F_3	F_4	G_4	F_1	F_2	F_3	F_4
	8	10	8	8		9	8	8	8
	9	9	7	9		7	7	7	9
	10	9	10	7		8	6	6	8
	9	10	8	6		9	8	8	7
	9	9	7	9		8	7	9	8

Illustration

Table 4: outlying degree of each possible subspaces

Feature	Outlying Degree	Feature	Outlying Degree
$\{F_1\}$	4.351	$\{F_2,F_3\}$	4.023
$\{F_2\}$	2.012	$\{F_3,F_4\}$	4.324
$\{F_3\}$	1.392	$\{F_2,F_4\}$	2.018
$\{F_4\}$	2.207	$\{F_2,F_3,F_4\}$	2.012

- Search process:

$OD(\{F_1\}) > \alpha$, save to T_1.

$OD(\{F_2\}) < \alpha$, save to C_1.

$OD(\{F_3\}) < \alpha$, save to C_2.

$OD(\{F_4\}) < \alpha$, save to C_3.

$OD(\{F_2,F_3\}) > \alpha$, save to N_1.

$OD(\{F_3,F_4\}) > \alpha$, save to N_2.

$OD(\{F_2,F_4\}) < \alpha$, remove.

$OD(\{F_2,F_3,F_4\}) < \alpha$, remove.

Strengths of GOAM Algorithm

- Reduction of Complexity
  - Bottom-up search strategy.
  - Reduce the size of candidate subspaces.
- Efficiency
  - Before: $O(2^d)$
    Now: $O(d * n^2)$

Evaluation Results

Evaluation

- $Accuracy = \frac{P}{T}$

  P: Identified outlying aspects

  T: Real outlying aspects

Synthetic Dataset

- Problem Definition1111
- Related Work and Challenges
- GOAM Algorithm
- Evaluation Results
- Synthetic Dataset
- NBA Dataset
- Conclusion

- Synthetic Dataset and Ground Truth

Table 5: Synthetic Dataset and Ground Truth

Query group	$\mathbf{F_1}$	$\mathbf{F_2}$	F_3	$\mathbf{F_4}$	F_5	F_6	F_7	F_8
i_1	**10**	**8**	9	**7**	7	6	6	8
i_2	**9**	**9**	7	**8**	9	9	8	9
i_3	**8**	**10**	8	**9**	6	8	7	8
i_4	**8**	**8**	6	**7**	8	8	6	7
i_5	**9**	**9**	9	**7**	7	7	8	8
i_6	**8**	**10**	8	**8**	6	6	8	7
i_7	**9**	**9**	7	**9**	8	8	8	7
i_8	**10**	**9**	10	**7**	7	7	7	7
i_9	**9**	**10**	8	**8**	7	6	7	7
i_{10}	**9**	**9**	7	**7**	7	8	8	8

Synthetic Dataset Results

Table 6: The experiment result on synthetic dataset

Method	Truth Outlying Aspects	Identified Aspects	Accuracy
GOAM	$\{F_1\}, \{F_2F_4\}$	$\{F_1\}, \{F_2F_4\}$	100%
Arithmetic Mean based OAM	$\{F_1\}, \{F_2F_4\}$	$\{F_4\}, \{F_2\}$	0%
Median based OAM	$\{F_1\}, \{F_2F_4\}$	$\{F_2\}, \{F_4\}$	0%

NBA Dataset

Data Collection

Source

Yahoo Sports website (`http://sports.yahoo.com.cn/nba`)

Data

- Extract NBA teams' data until March 30, 2018;
- 6 divisions;
- 12 features (eg: *Point Scored*).

NBA Dataset

The detail features are as follows:

Table 7: Collected data of Brooklyn Nets Team

Pts	FGA	FG%	3FA	3PT%	FTA	FT%	Reb	Ass	To	Stl	Blk
18	12	42	2.00	50	7.00	100	0	4	3	0	0
15.7	14.07	41	5.45	32	3.05	75	3.98	5.1	2.98	0.69	0.36
14.5	11.1	47	0.82	26	4.87	78	6.82	2.4	1.74	0.92	0.66
13.5	10.8	42	5.37	37	3.38	77	6.66	2	1.38	0.83	0.42
12.7	10.59	39	5.36	33	3.37	82	3.24	6.6	1.56	0.89	0.31
12.6	10.93	40	6.94	37	1.70	84	4.27	1.5	1.06	0.61	0.44
12.2	10.39	44	3.42	35	2.70	72	3.79	4.1	2.15	1.12	0.32
10.6	7.85	49	4.51	41	1.35	83	3.34	1.6	1.15	0.45	0.24

NBA Dataset

- Data Preprocess

Table 8: The bins that used to discrete data of each feature

Labels	Pts	FGA	FG%	3FA	3PT%	FTA
low	[0,5]	[0,4]	[0,0.35]	[0,1.0]	[0,0.2]	[0,1.0]
medium	(5,10]	(4,7]	(0.35,0.45]	(1.0,2.5]	(0.2,0.3]	(1.0,1.5]
high	(10,15]	(7,10]	(0.45,0.5]	(2.5,3.5]	(0.3,0.35]	(1.5,2.5]
very high	(15,+∞]	(10,+∞]	(0.5,1]	(3.5,+∞]	(0.35,1]	(2.5,+∞]
Labels	FT%	Reb	Ass	To	Stl	Blk
low	[0,0.6]	[0,2.0]	[0,1.0]	[0,0.6]	[0,0.2]	[0,0.25]
medium	(0.6,0.65]	(2,5]	(1,2]	(0.6,0.9]	(0.2,0.5]	(0.25,0.5]
high	(0.65,0.75]	(5,6]	(2,4]	(0.9,1.7]	(0.6,0.75]	(0.5,0.7]
very high	(0.75,1]	(6,+∞]	(4,+∞]	(1.7,+∞]	(0.75,+∞]	(0.7,+∞]

NBA Dataset Results

Table 9: The identified outlying aspects of groups

Teams	Trivial Outlying Aspects	NonTrivial Outlying Aspects
Cleveland Cavaliers	{3FA}	{FGA, FT%}, {FGA, FG%}
Orlando Magic	{Stl}	None
Milwaukee Bucks	{To}, {FTA}	{FGA, FTA}, {3FA, FTA}
Golden State Warriors	{FG%}	{FT%, Blk}, {FGA, 3PT%, FTA}
Utah Jazz	{Blk}	{3FA, 3PT%}
New Orleans Pelicans	{FT%}, {FTA}	{FTA, Stl}, {FTA, To}

Conclusion

Conclusion

Problem Definition1111

Related Work and Challenges

GOAM Algorithm

Evaluation Results

Conclusion

- Formalize the problem of *Group Outlying Aspects Mining* by extending outlying aspects mining;
- Propose a novel method GOAM algorithm to solve the *Group Outlying Aspects Mining* problem;
- Utilize the pruning strategies to reduce time complexity.

Questions?

Contact Information

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