Biclustering Based on FCA and Partition Pattern Structures for Recommendation Systems

Nyoman Juniarta[1] Victor Codocedo[2] Miguel Couceiro[1] Amedeo Napoli[1]

[1] Université de Lorraine, CNRS, Inria, LORIA, F-54000 Nancy, France

[2] Universidad Técnica Federico Santa María, Santiago, Chile

July 13, 2018

UNIVERSIDAD TECNICA
FEDERICO SANTA MARIA

Outline

Context

- An European project who support the emergence of a European cultural heritage by allowing visitors in different cultural sites to improve the quality of their visit by using adapted computer-based devices and to consider the visit at a European level.

Context

- An European project who support the emergence of a European cultural heritage by allowing visitors in different cultural sites to improve the quality of their visit by using adapted computer-based devices and to consider the visit at a European level.
- Such improvement can be accomplished by studying a dynamic recommendation system.

Objective

- Collaborative recommendations: studying previous users who have similar interest to a target user.

Objective

- Collaborative recommendations: studying previous users who have similar interest to a target user.
- Using biclustering to retrieve similar users.

Objective

- Collaborative recommendations: studying previous users who have similar interest to a target user.
- Using biclustering to retrieve similar users.
- Using partition pattern structures to obtain biclusters.

Outline

Biclustering

Simultaneous clustering of both rows and columns of a data matrix.

A matrix

4	2	5	3	3
4	2	5	3	3
4	3	5	2	2
2	1	3	9	7
8	3	9	8	6

Biclustering

Simultaneous clustering of both rows and columns of a data matrix.

A constant-value bicluster

4	2	5	3	3
4	2	5	3	3
4	3	5	2	2
2	1	3	9	7
8	3	9	8	6

Biclustering

A constant-columns (CC) bicluster

4	2	5	3	3
4	2	5	3	3
4	3	5	2	2
2	1	3	9	7
8	3	9	8	6

A constant-rows bicluster

4	2	5	3	3
4	2	5	3	3
4	3	5	2	2
2	1	3	9	7
8	3	9	8	6

A coherent-evolution-on-columns (CEC) bicluster

4	2	5	3	3
4	2	5	3	3
4	3	5	2	2
2	1	3	9	7
8	3	9	8	6

A coherent-evolution-on-rows bicluster

4	2	5	3	3
4	2	5	3	3
4	3	5	2	2
2	1	3	9	7
8	3	9	8	6

Outline

Outline

Partition

Definition

A partition $\mathtt{d} = \{p_i\}$ of a set $\mathtt{G}$ is a collection of $p_i \subseteq \mathtt{G}$ such that:

$$\bigcup_{p_i \in \mathtt{d}} p_i = \mathtt{G} \quad \text{and} \quad p_i \cap p_j = \emptyset \quad \text{whenever} \quad i \neq j.$$

Partition

Definition

A partition $\mathtt{d} = \{p_i\}$ of a set $\mathtt{G}$ is a collection of $p_i \subseteq \mathtt{G}$ such that:

$$\bigcup_{p_i \in \mathtt{d}} p_i = \mathtt{G} \quad \text{and} \quad p_i \cap p_j = \emptyset \quad \text{whenever} \quad i \neq j.$$

Given $\mathtt{G}$ = set of objects, and $\mathtt{M}$ = set of attributes, $\delta : \mathtt{M} \to \mathtt{D}$.

Partition

Definition

A partition $\mathtt{d} = \{p_i\}$ of a set $\mathtt{G}$ is a collection of $p_i \subseteq \mathtt{G}$ such that:

$$\bigcup_{p_i \in \mathtt{d}} p_i = \mathtt{G} \quad \text{and} \quad p_i \cap p_j = \emptyset \quad \text{whenever} \quad i \neq j.$$

Given $\mathtt{G}$ = set of objects, and $\mathtt{M}$ = set of attributes, $\delta : \mathtt{M} \to \mathtt{D}$.

Example

	$\mathtt{m}_1$	$\mathtt{m}_2$	$\mathtt{m}_3$	$\mathtt{m}_4$	$\mathtt{m}_5$
$\mathtt{g}_1$	1	5	3	4	7
$\mathtt{g}_2$	1	1	4	2	7
$\mathtt{g}_3$	2	5	4	5	3
$\mathtt{g}_4$	2	5	4	5	7

$$\delta(\mathtt{m}_1) = \{\{\mathtt{g}_1, \mathtt{g}_2\}, \{\mathtt{g}_3, \mathtt{g}_4\}\}$$
$$\delta(\mathtt{m}_2) = \{\{\mathtt{g}_2\}, \{\mathtt{g}_1, \mathtt{g}_3, \mathtt{g}_4\}\}$$
$$\delta(\mathtt{m}_3) = \{\{\mathtt{g}_1\}, \{\mathtt{g}_2, \mathtt{g}_3, \mathtt{g}_4\}\}$$
$$\delta(\mathtt{m}_4) = \{\{\mathtt{g}_1\}, \{\mathtt{g}_2\}, \{\mathtt{g}_3, \mathtt{g}_4\}\}$$
$$\delta(\mathtt{m}_5) = \{\{\mathtt{g}_3\}, \{\mathtt{g}_1, \mathtt{g}_2, \mathtt{g}_4\}\}$$

Meet and Join

Definition

The meet and join of two partitions $\mathrm{d}_1 = \{p_i\}$ and $\mathrm{d}_2 = \{p_j\}$ are defined as:

$$\mathrm{d}_1 \sqcap \mathrm{d}_2 = \bigcup_{i,j} \{p_i \cap p_j\} \qquad \mathrm{d}_1 \sqcup \mathrm{d}_2 = \left(\bigcup_{p_i \cap p_j \neq \emptyset} \{p_i \cup p_j\} \right)^+$$

Meet and Join

Definition

The meet and join of two partitions $\mathrm{d}_1 = \{p_i\}$ and $\mathrm{d}_2 = \{p_j\}$ are defined as:

$$\mathrm{d}_1 \sqcap \mathrm{d}_2 = \bigcup_{i,j} \{p_i \cap p_j\} \qquad \mathrm{d}_1 \sqcup \mathrm{d}_2 = \left(\bigcup_{p_i \cap p_j \neq \emptyset} \{p_i \cup p_j\} \right)^+$$

$$\mathrm{d}_1 \sqsubseteq \mathrm{d}_2 \iff \mathrm{d}_1 \sqcap \mathrm{d}_2 = \mathrm{d}_1$$

Meet and Join

Definition

The meet and join of two partitions $\mathrm{d}_1 = \{p_i\}$ and $\mathrm{d}_2 = \{p_j\}$ are defined as:

$$\mathrm{d}_1 \sqcap \mathrm{d}_2 = \bigcup_{i,j} \{p_i \cap p_j\} \qquad \mathrm{d}_1 \sqcup \mathrm{d}_2 = \left(\bigcup_{p_i \cap p_j \neq \emptyset} \{p_i \cup p_j\} \right)^+$$

$$\mathrm{d}_1 \sqsubseteq \mathrm{d}_2 \iff \mathrm{d}_1 \sqcap \mathrm{d}_2 = \mathrm{d}_1$$

Example

$\delta(\mathrm{m}_1) = \{\{\mathrm{g}_1, \mathrm{g}_2\}, \{\mathrm{g}_3, \mathrm{g}_4\}\}$
$\delta(\mathrm{m}_2) = \{\{\mathrm{g}_2\}, \{\mathrm{g}_1, \mathrm{g}_3, \mathrm{g}_4\}\}$
$\delta(\mathrm{m}_3) = \{\{\mathrm{g}_1\}, \{\mathrm{g}_2, \mathrm{g}_3, \mathrm{g}_4\}\}$
$\delta(\mathrm{m}_4) = \{\{\mathrm{g}_1\}, \{\mathrm{g}_2\}, \{\mathrm{g}_3, \mathrm{g}_4\}\}$
$\delta(\mathrm{m}_5) = \{\{\mathrm{g}_3\}, \{\mathrm{g}_1, \mathrm{g}_2, \mathrm{g}_4\}\}$

$\delta(\mathrm{m}_1) \sqcap \delta(\mathrm{m}_2) = \{\{\mathrm{g}_1\}, \{\mathrm{g}_2\}, \{\mathrm{g}_3, \mathrm{g}_4\}\}$
$\delta(\mathrm{m}_1) \sqcup \delta(\mathrm{m}_2) =$
$\{\{\mathrm{g}_1, \mathrm{g}_2\}, \{\mathrm{g}_1, \mathrm{g}_2, \mathrm{g}_3, \mathrm{g}_4\}, \{\mathrm{g}_1, \mathrm{g}_3, \mathrm{g}_4\}\}^+$
$= \{\{\mathrm{g}_1, \mathrm{g}_2, \mathrm{g}_3, \mathrm{g}_4\}\}$

Partition Pattern Concept

Definition

A partition pattern structures for CC biclustering is determined by the triple $(\mathtt{M}, (\mathtt{D}, \sqcap), \delta)$.
A pair $(\mathtt{A}, \mathtt{d})$ is then called a partition pattern concept (pp-concept) iff $\mathtt{A}^{\square} = \mathtt{d}$ and $\mathtt{d}^{\square} = \mathtt{A}$, where:

$$\mathtt{A}^{\square} = \bigsqcap_{\mathtt{m} \in \mathtt{A}} \delta(\mathtt{m}) \qquad \mathtt{A} \subseteq \mathtt{M}$$

$$\mathtt{d}^{\square} = \{\mathtt{m} \in \mathtt{M} | \mathtt{d} \sqsubseteq \delta(\mathtt{m})\} \qquad \mathtt{d} \in \mathtt{D}$$

Partition Pattern Concept

Definition

A partition pattern structures for CC biclustering is determined by the triple $(\mathtt{M}, (\mathtt{D}, \sqcap), \delta)$.
A pair $(\mathtt{A}, \mathtt{d})$ is then called a partition pattern concept (pp-concept) iff $\mathtt{A}^{\square} = \mathtt{d}$ and $\mathtt{d}^{\square} = \mathtt{A}$, where:

$$\mathtt{A}^{\square} = \bigsqcap_{\mathtt{m} \in \mathtt{A}} \delta(\mathtt{m}) \qquad \mathtt{A} \subseteq \mathtt{M}$$

$$\mathtt{d}^{\square} = \{\mathtt{m} \in \mathtt{M} | \mathtt{d} \sqsubseteq \delta(\mathtt{m})\} \qquad \mathtt{d} \in \mathtt{D}$$

For any partition component $p \in \mathtt{d}$, each pair $(p, \mathtt{A})$ corresponds to a CC bicluster.

Partition Pattern Concept

Example

	m_1	m_2	m_3	m_4	m_5
g_1	1	5	3	4	7
g_2	1	1	4	2	7
g_3	2	5	4	5	3
g_4	2	5	4	5	7

Partition Pattern Concept

Example

	m_1	m_2	m_3	m_4	m_5
g_1	1	5	3	4	7
g_2	1	1	4	2	7
g_3	2	5	4	5	3
g_4	2	5	4	5	7

A pp-concept: $(\{m_1, m_2, m_3, m_4\}, \{\{g_1\}, \{g_2\}, \{g_3, g_4\}\})$.

Partition Pattern Concept

Example

	m_1	m_2	m_3	m_4	m_5
g_1	1	5	3	4	7
g_2	1	1	4	2	7
g_3	2	5	4	5	3
g_4	2	5	4	5	7

A pp-concept: $(\{m_1, m_2, m_3, m_4\}, \{\{g_1\}, \{g_2\}, \{g_3, g_4\}\})$.
CC biclusters:

- $(\{g_1\}, \{m_1, m_2, m_3, m_4\})$
- $(\{g_2\}, \{m_1, m_2, m_3, m_4\})$
- $(\{g_3, g_4\}, \{m_1, m_2, m_3, m_4\})$

Outline

Recommendation

The rating of $\mathtt{I}$ (a set of items) according to $\mathtt{V}$ (a set of visitors)

	$\mathtt{i}_1$	$\mathtt{i}_2$	$\mathtt{i}_3$	$\mathtt{i}_4$	$\mathtt{i}_5$
$\mathtt{v}_1$	1	1	3	2	3
$\mathtt{v}_2$	1	1	3	2	3
$\mathtt{v}_3$	1	1	3	2	2
$\mathtt{v}_4$	3	2	1	3	1
$\mathtt{v}_5$	3	2	1	3	1
$\mathtt{v}_6$	3	1	2	2	3
$\mathtt{v}_7$	3	1	2	2	3
$\mathtt{v}_8$	2	3	3	2	2
$\mathtt{v}_9$	3	2	3	3	3
$\mathtt{v}_t$	?	?	?	1	3

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	1	3	2	3
v_2	1	1	3	2	3
v_3	1	1	3	2	2
v_4	3	2	1	3	1
v_5	3	2	1	3	1
v_6	3	1	2	2	3
v_7	3	1	2	2	3
v_8	2	3	3	2	2
v_9	3	2	3	3	3
v_t	?	?	?	1	3

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	1	3	2	3
v_2	1	1	3	2	3
v_3	1	1	3	2	2
v_4	3	2	1	3	1
v_5	3	2	1	3	1
v_6	3	1	2	2	3
v_7	3	1	2	2	3
v_8	2	3	3	2	2
v_9	3	2	3	3	3
v_t	?	?	?	1	3

Recommendation for v_t: i_3

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	1	3	2	3
v_2	1	1	3	2	3
v_3	1	1	3	2	2
v_4	3	2	1	3	1
v_5	3	2	1	3	1
v_6	3	1	2	2	3
v_7	3	1	2	2	3
v_8	2	3	3	2	2
v_9	3	2	3	3	3
v_t	?	?	?	1	3

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	1	3	2	3
v_2	1	1	3	2	3
v_3	1	1	3	2	2
v_4	3	2	1	3	1
v_5	3	2	1	3	1
v_6	3	1	2	2	3
v_7	3	1	2	2	3
v_8	2	3	3	2	2
v_9	3	2	3	3	3
v_t	?	?	?	1	3

Recommendation for v_t: i_3

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	1	3	2	3
v_2	1	1	3	2	3
v_3	1	1	3	2	2
v_4	3	2	1	3	1
v_5	3	2	1	3	1
v_6	3	1	2	2	3
v_7	3	1	2	2	3
v_8	2	3	3	2	2
v_9	3	2	3	3	3
v_t	?	?	?	1	3

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	1	3	2	3
v_2	1	1	3	2	3
v_3	1	1	3	2	2
v_4	3	2	1	3	1
v_5	3	2	1	3	1
v_6	3	1	2	2	3
v_7	3	1	2	2	3
v_8	2	3	3	2	2
v_9	3	2	3	3	3
v_t	?	?	?	1	3

v_3 may dislike i_1 and like i_3.

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	1	3	2	3
v_2	1	1	3	2	3
v_3	1	1	3	2	2
v_4	3	2	1	3	1
v_5	3	2	1	3	1
v_6	3	1	2	2	3
v_7	3	1	2	2	3
v_8	2	3	3	2	2
v_9	3	2	3	3	3
v_t	?	?	?	1	3

v_3 may dislike i_1 and like i_3.
Recommendation for v_t: i_3

Outline

CEC Biclustering

A coherent-evolution-on-columns (CEC) bicluster

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

Outline

Partition

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

$p_{1,2} = (m_1, m_2)$

Partition

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

$P_{1,2} = (m_1, m_2)$
$\gamma : P \rightarrow D$

Partition

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

$p_{1,2} = (m_1, m_2)$
$\gamma : P \rightarrow D$
$\gamma(p_{1,2}) = \{\{g_1, g_3\}, \{g_2, g_4, g_5\}\}$

Partition

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

$p_{1,4} = (m_1, m_4)$
$\gamma : P \rightarrow D$
$\gamma(p_{1,4}) = \{\{g_1, g_2, g_5\}, \{g_2, g_3, g_4\}\}$

Partition

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

$p_{4,5} = (m_4, m_5)$

$\gamma : P \rightarrow D$

$\gamma(p_{4,5}) = \{\{g_1, g_2, g_3\}, \{g_2, g_3, g_4, g_5\}\}$

Meet and Join

Definition

The meet and join of two partitions $\mathrm{d}_1 = \{p_i\}$ and $\mathrm{d}_2 = \{p_j\}$ are defined as:

$$\mathrm{d}_1 \sqcap \mathrm{d}_2 = \left(\bigcup_{i,j} \{p_i \cap p_j\} \right)^+ \qquad \mathrm{d}_1 \sqcup \mathrm{d}_2 = \left(\bigcup_{p_i \cap p_j \neq \emptyset} \{p_i \cup p_j\} \right)^+$$

$$\mathrm{d}_1 \sqsubseteq \mathrm{d}_2 \iff \mathrm{d}_1 \sqcap \mathrm{d}_2 = \mathrm{d}_1$$

Meet and Join

Definition

The meet and join of two partitions $\mathrm{d}_1 = \{p_i\}$ and $\mathrm{d}_2 = \{p_j\}$ are defined as:

$$\mathrm{d}_1 \sqcap \mathrm{d}_2 = \left(\bigcup_{i,j} \{p_i \cap p_j\} \right)^+ \qquad \mathrm{d}_1 \sqcup \mathrm{d}_2 = \left(\bigcup_{p_i \cap p_j \neq \emptyset} \{p_i \cup p_j\} \right)^+$$

$$\mathrm{d}_1 \sqsubseteq \mathrm{d}_2 \iff \mathrm{d}_1 \sqcap \mathrm{d}_2 = \mathrm{d}_1$$

Example

$\gamma(\mathrm{p}_{1,2}) = \{\{\mathrm{g}_1, \mathrm{g}_3\}, \{\mathrm{g}_2, \mathrm{g}_4, \mathrm{g}_5\}\}$
$\gamma(\mathrm{p}_{1,4}) = \{\{\mathrm{g}_1, \mathrm{g}_2, \mathrm{g}_5\}, \{\mathrm{g}_2, \mathrm{g}_3, \mathrm{g}_4\}\}$
$\gamma(\mathrm{p}_{1,2}) \sqcap \gamma(\mathrm{p}_{1,4}) = \{\{\mathrm{g}_1\}, \{\mathrm{g}_3\}, \{\mathrm{g}_2, \mathrm{g}_5\}, \{\mathrm{g}_2, \mathrm{g}_4\}\}$

Partition Pattern Concept

Definition

A partition pattern structures for CEC biclustering is determined by the triple $(\mathtt{P}, (\mathtt{D}, \sqcap), \gamma)$.
A pair $(\mathtt{B}, \mathtt{d})$ is then called a partition pattern concept (pp-concept) iff $\mathtt{B}^{\square} = \mathtt{d}$ and $\mathtt{d}^{\square} = \mathtt{B}$, where:

$$\mathtt{B}^{\square} = \bigsqcap_{\mathtt{p} \in \mathtt{B}} \gamma(\mathtt{p}) \qquad \mathtt{B} \subseteq \mathtt{P}$$

$$\mathtt{d}^{\square} = \{\mathtt{p} \in \mathtt{P} | \mathtt{d} \sqsubseteq \gamma(\mathtt{p})\} \qquad \mathtt{d} \in \mathtt{D}$$

Partition Pattern Concept

Definition

A partition pattern structures for CEC biclustering is determined by the triple $(\mathtt{P}, (\mathtt{D}, \sqcap), \gamma)$.
A pair $(\mathtt{B}, \mathtt{d})$ is then called a partition pattern concept (pp-concept) iff $\mathtt{B}^{\square} = \mathtt{d}$ and $\mathtt{d}^{\square} = \mathtt{B}$, where:

$$\mathtt{B}^{\square} = \bigsqcap_{\mathtt{p} \in \mathtt{B}} \gamma(\mathtt{p}) \qquad \mathtt{B} \subseteq \mathtt{P}$$

$$\mathtt{d}^{\square} = \{\mathtt{p} \in \mathtt{P} | \mathtt{d} \sqsubseteq \gamma(\mathtt{p})\} \qquad \mathtt{d} \in \mathtt{D}$$

A pp-concept contains a CEC bicluster if there is a clique among the attributes in the pairs.

Partition Pattern Concept

Example

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

Partition Pattern Concept

Example

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

A pp-concept: $\{\{p_{1,2}, p_{1,3}, p_{2,3}\}, \{\{g_1, g_3\}, \{g_5\}, \{g_2, g_4\}\}\}$

Partition Pattern Concept

Example

	m_1	m_2	m_3	m_4	m_5
g_1	1	2	3	4	5
g_2	4	2	1	?	3
g_3	2	3	4	1	1
g_4	5	4	2	3	1
g_5	2	1	5	4	3

A pp-concept: $\{\{p_{1,2}, p_{1,3}, p_{2,3}\}, \{\{g_1, g_3\}, \{g_5\}, \{g_2, g_4\}\}\}$
Biclusters:

- $(\{g_1, g_3\}, \{m_1, m_2, m_3\})$
- $(\{g_2, g_4\}, \{m_1, m_2, m_3\})$
- $(\{g_5\}, \{m_1, m_2, m_3\})$

Outline

Recommendation

Order of visit of 7 items

	i_1	i_2	i_3	i_4	i_5	i_6	i_7
v_1	1	2	3	4	5	6	7
v_2	2	4	5	3	7	1	6
v_3	4	2	1	5	6	3	7
v_4	7	3	1	4	2	6	5
v_t	?	?	1	2	?	?	?

Recommendation

	i_1	i_2	i_3	i_4	i_5	i_6	i_7
v_1	1	2	3	4	5	6	7
v_2	2	4	5	3	7	1	6
v_3	4	2	1	5	6	3	7
v_4	7	3	1	4	2	6	5
v_t	?	?	1	2	?	?	?

Recommendation for v_t: i_5.

Recommendation

Order of interest of 5 items

	i_1	i_2	i_3	i_4	i_5
v_1	1	2	3	4	5
v_2	3	?	4	2	1
v_3	2	4	3	?	1
v_t	1	1	2	?	?

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	2	3	4	5
v_2	3	?	4	2	1
v_3	2	4	3	?	1
v_t	1	1	2	?	?

Recommendation

	i_1	i_2	i_3	i_4	i_5
v_1	1	2	3	4	5
v_2	3	?	4	2	1
v_3	2	4	3	?	1
v_t	1	1	2	?	?

Recommendation for v_t: i_5.

Outline

Conclusion

- We have explored the approaches to build collaborative recommendation strategies for visitors in a museum.

Conclusion

- We have explored the approaches to build collaborative recommendation strategies for visitors in a museum.
- We also presented a technique for mining `CC` and `CEC` biclusters based on FCA using pattern structures.

Conclusion

- We have explored the approaches to build collaborative recommendation strategies for visitors in a museum.
- We also presented a technique for mining `CC` and `CEC` biclusters based on FCA using pattern structures.
- Comparison of `CEC` biclustering with sequential pattern mining?

Conclusion

- We have explored the approaches to build collaborative recommendation strategies for visitors in a museum.
- We also presented a technique for mining `CC` and `CEC` biclusters based on FCA using pattern structures.
- Comparison of `CEC` biclustering with sequential pattern mining?
- Filtering the biclusters based on "score"?

Conclusion

- We have explored the approaches to build collaborative recommendation strategies for visitors in a museum.
- We also presented a technique for mining `CC` and `CEC` biclusters based on FCA using pattern structures.
- Comparison of `CEC` biclustering with sequential pattern mining?
- Filtering the biclusters based on "score"?
- Implementation of `CEC` biclustering?

Thank you