A graph modeling strategy for multi-touch handwritten gesture recognition

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14th International Conference on Frontiers in Handwriting Recognition
Greece, 2 September 2014

intuidoc
intuitive user-interaction for document

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Outline

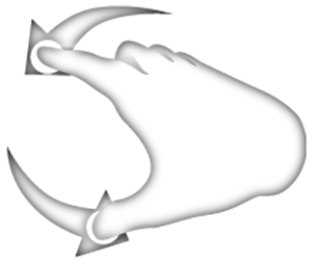
- Background and Problem
- Graph Representation
- Experimentation

Background

- Development of touch screen technic gives a more convenient way for Human-computer interaction (HCI)

Background

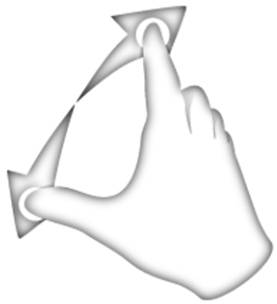
- Some common used multi-touch gestures for direct manipulation.



- Rotate left

- Rotate right

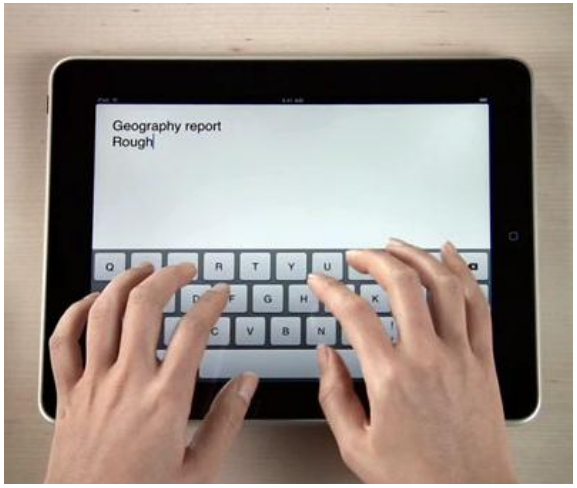
- Pinch for zoom out



- Spread for zoom in

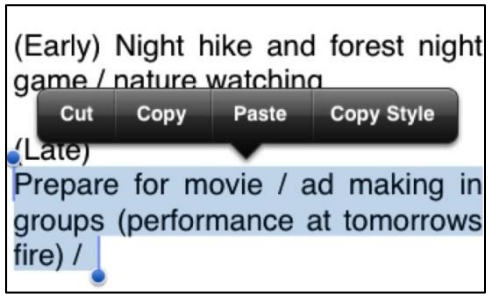
Why we study the multi-touch gesture recognition

- **In a text editing context**

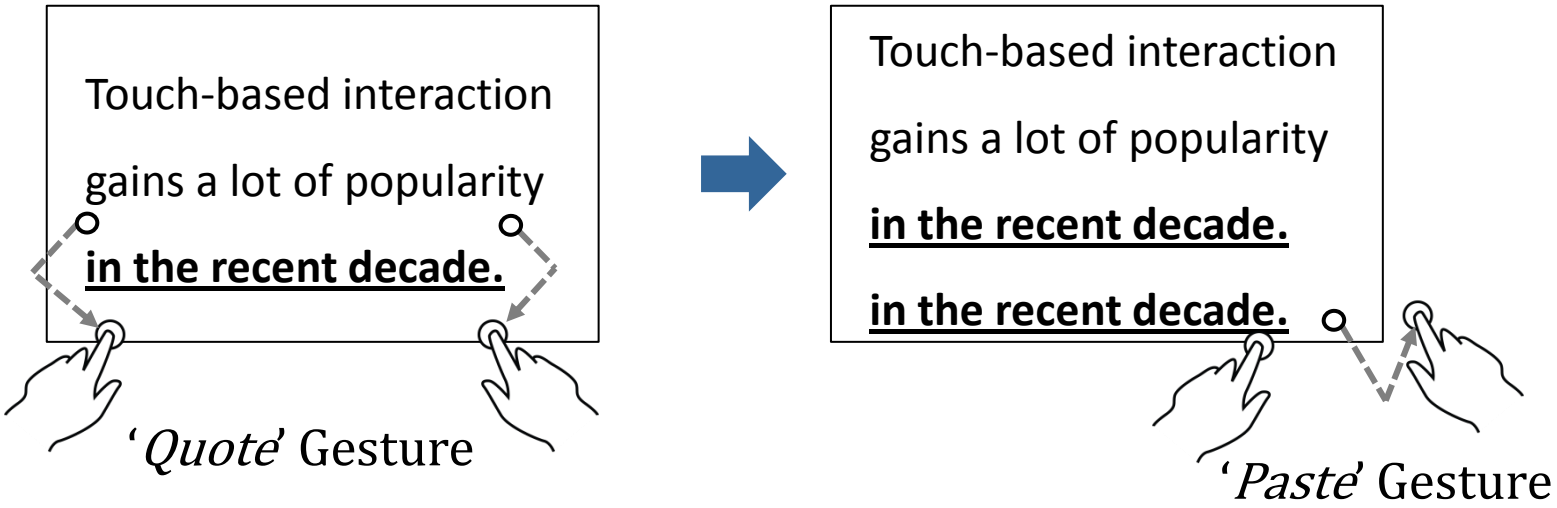


How to make a copy & paste operation?

- Menu based

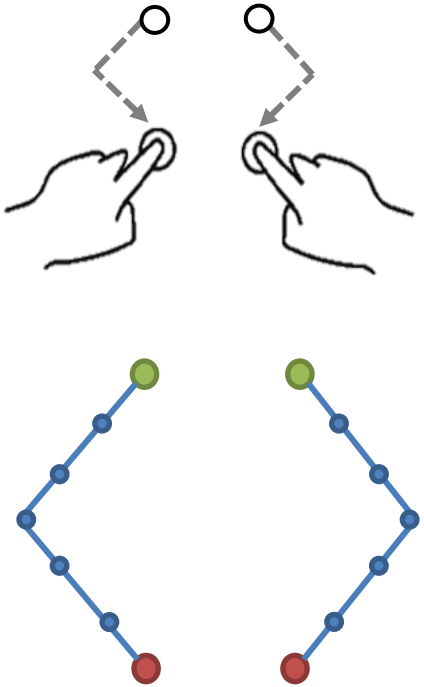


- Gesture based



Feature representation of multi-touch gesture

- **Feature based recognition system**:



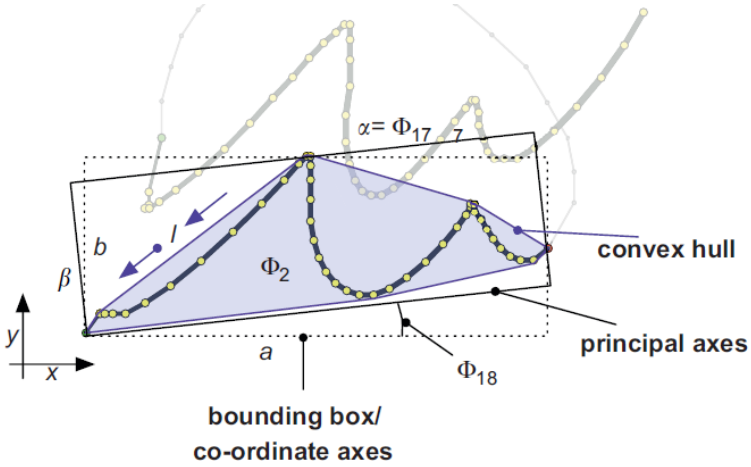


Fig. 1. g-48 feature [1] Φ_2, Φ_{17} and Φ_{18}: area, length and orientation

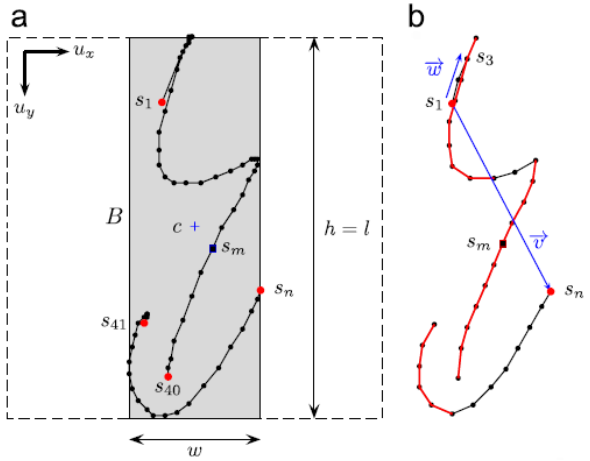


Fig. 2. HBF49 feature [2] (a) bounding box and gravity center. (b) First-to-last vector in blue, downstrokes in red.

[1]. Don Willems, Ralph Niels, Marcel van Gerven, Louis Vuurpijl. Iconic and multi-stroke gesture recognition. Pattern recognition 42(2009) 3303-3312.

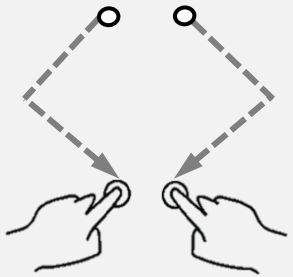
[2]. Adrien Delaye, Eric Anquetil. HBF49 feature set: A first unified baseline for online symbol recognition. Pattern recognition 46(2013) 117-130.

Feature representation of multi-touch gesture

Why not feature based method?

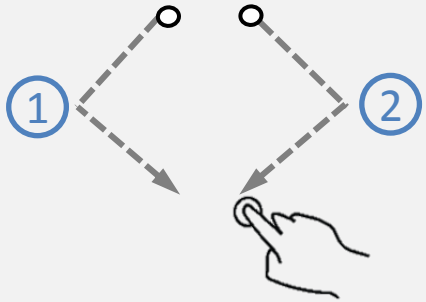
- ✔ Shape information
- ✔ Spatial relationship between strokes
- ✖ Temporal relationship between strokes

Synchronous writing



≠

Asynchronous writing



Outline

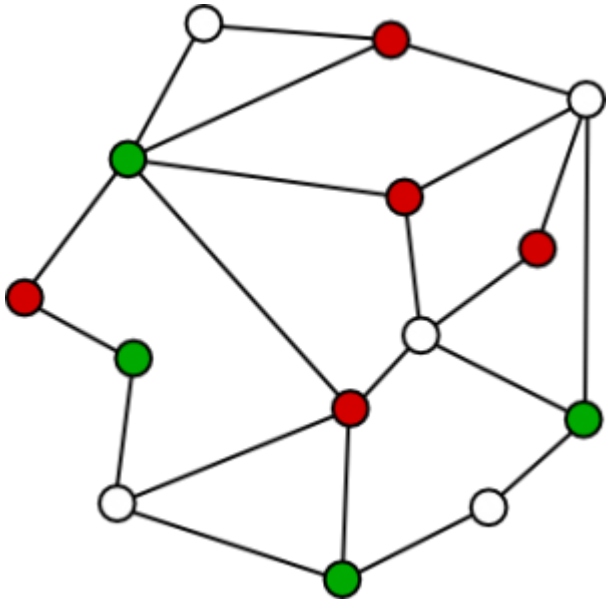
- Background and Problem
- Graph Representation
- Experimentation

Graph Representation

- **Using graph to represent the gesture**

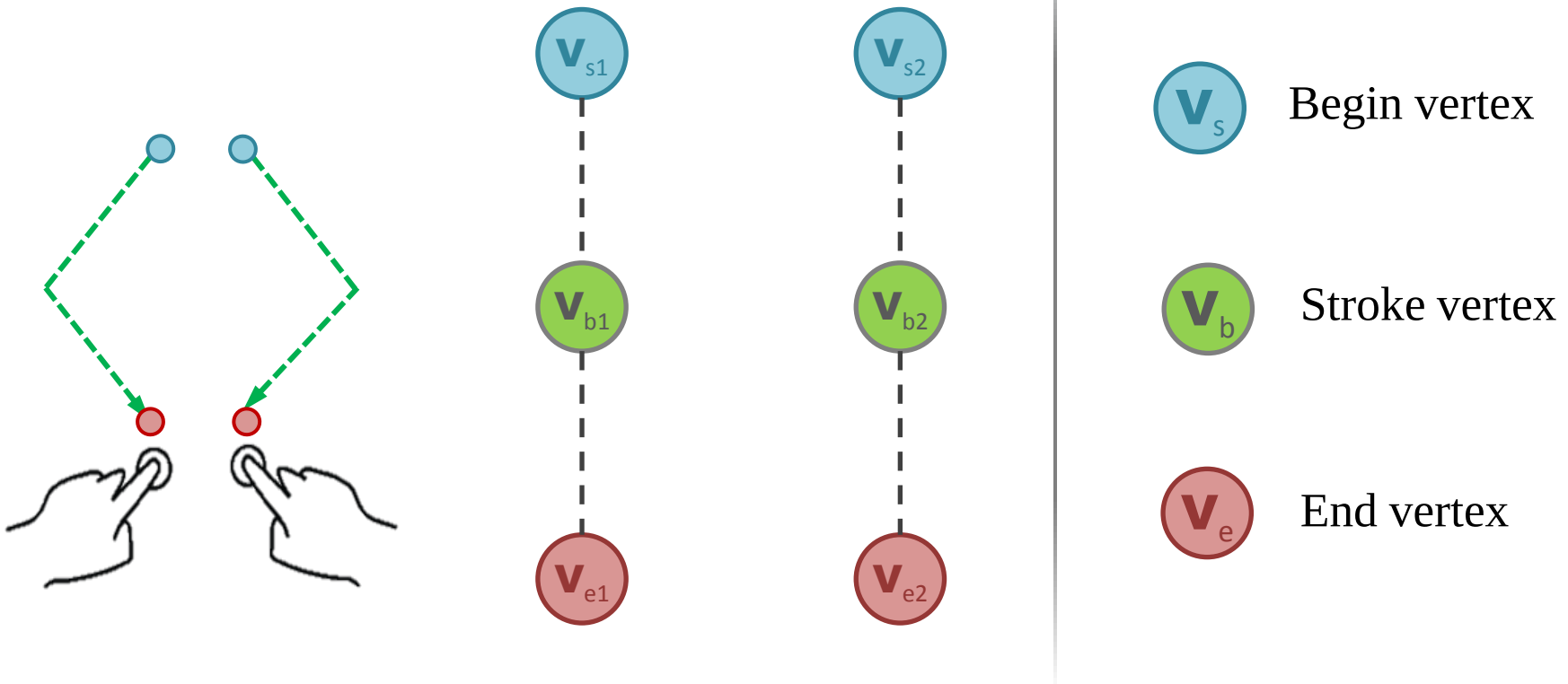
$$G=(\mathcal{V},\mathcal{E},\mu,\nu)$$

- $\mathcal{V}$ is the set of nodes
- $\mathcal{E} \subseteq \mathcal{V} \times \mathcal{V}$ is the set of edges
- $\mu: \mathcal{V} \rightarrow \mathcal{L}_{\mathcal{V}}$ is the node labeling function
- $\nu: \mathcal{E} \rightarrow \mathcal{L}_{\mathcal{E}}$ is the edge labeling function



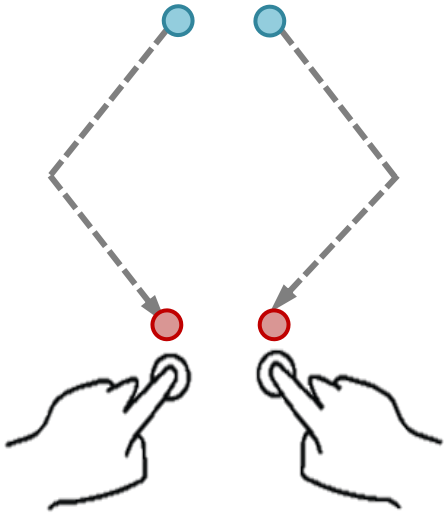
Graph Representation

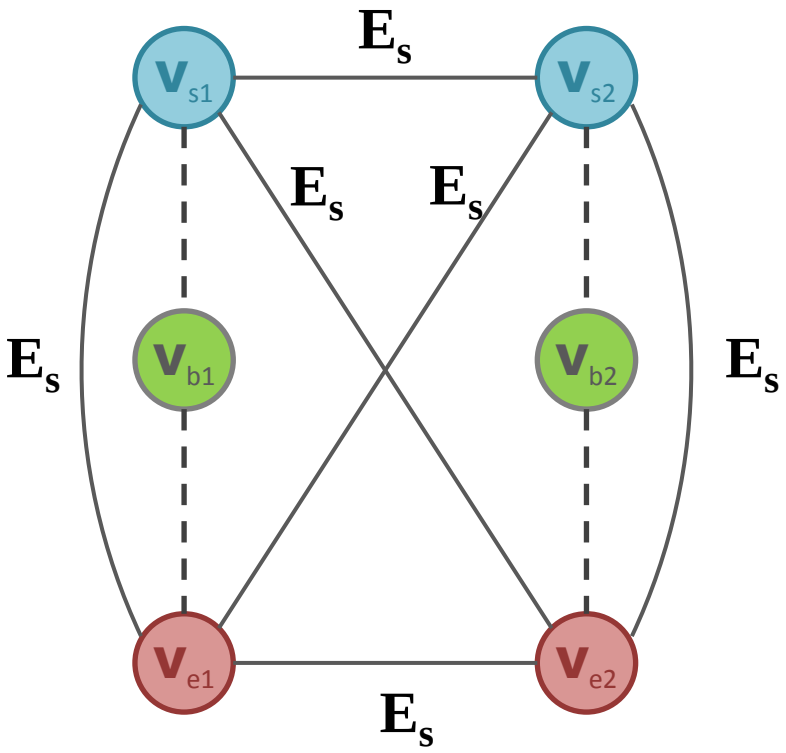
- **Each stroke is represented by 3 vertices.**



Graph Representation : Edge

- **Step 1. Spatial relationship between begin and end vertices: E_s**

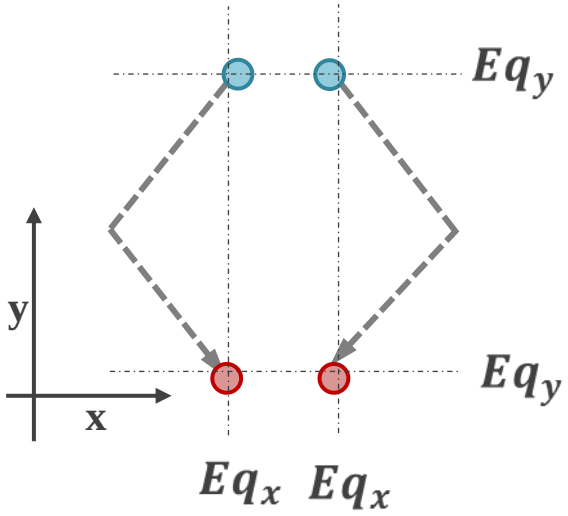


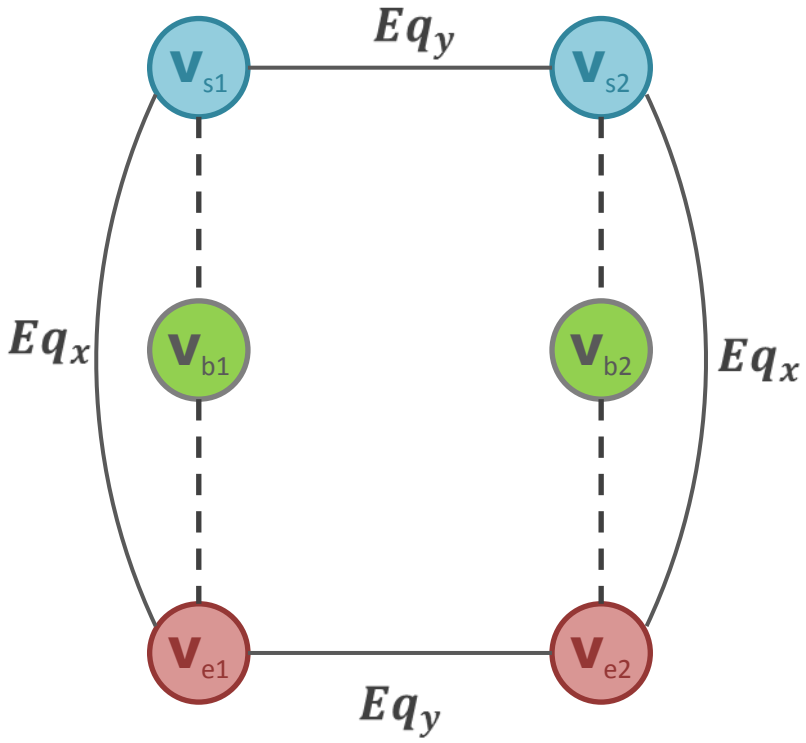


Graph Representation : Edge

- **Step 1. Spatial relationship between begin and end vertices: E_s**
  - Preserve the edges which have the equal spatial relationships.

Spatial domain



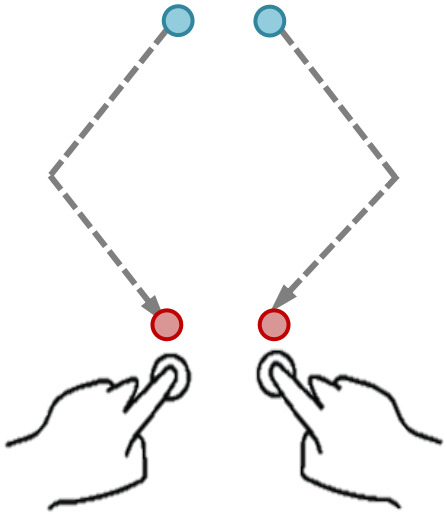


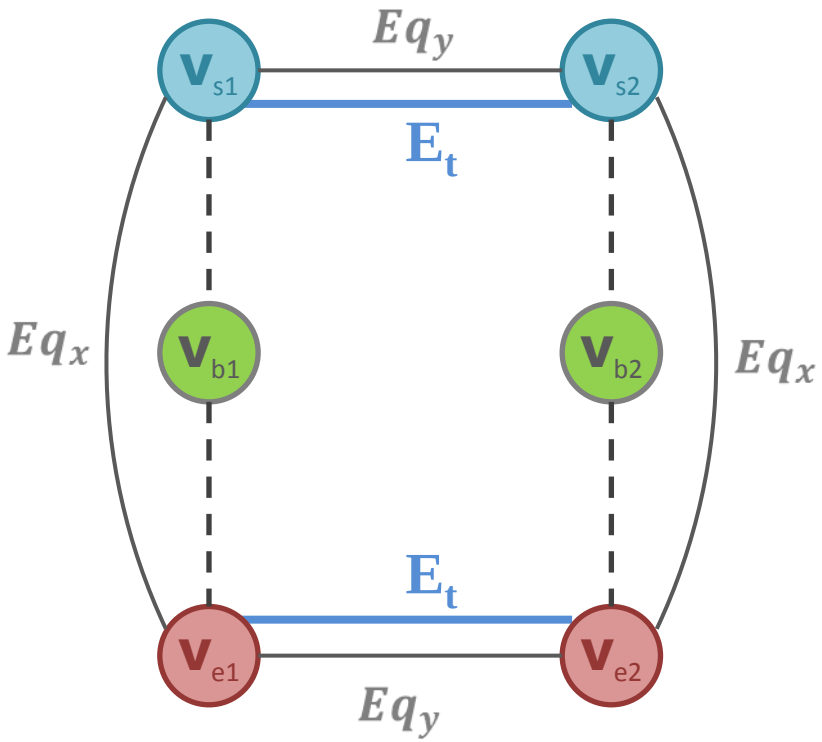
$E_s \in \{Equal_x, Equal_y\}$

i.e. the edge E_s measures

Graph Representation : Edge

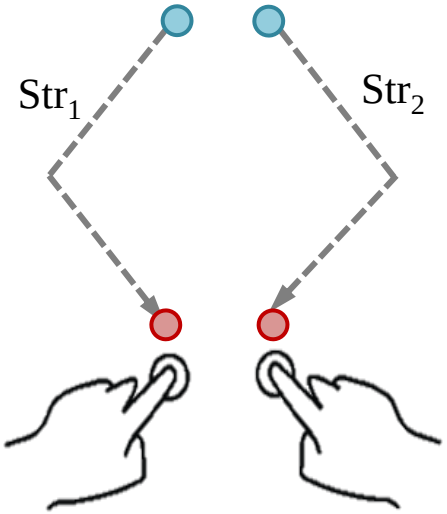
- **Step 2. Temporal relationship between begin and end vertices. E_t**



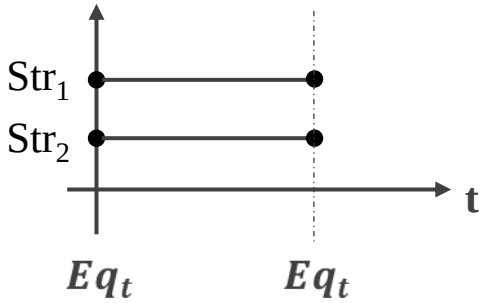


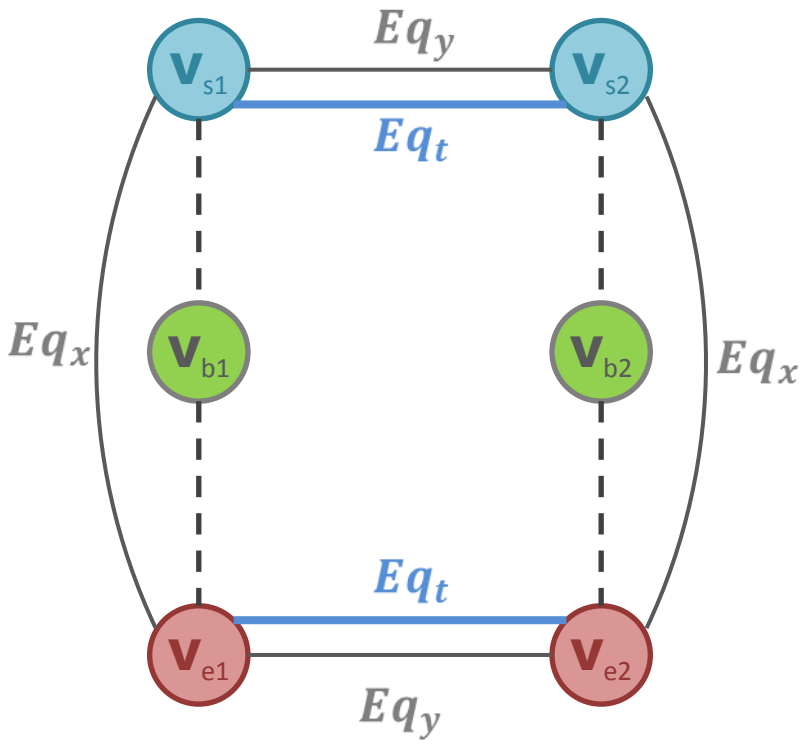
Graph Representation : Edge

- **Step 2. Temporal relationship between begin and end vertices. E_t**
  - Preserve the edges which have the equal temporal relationships.



- Time domain



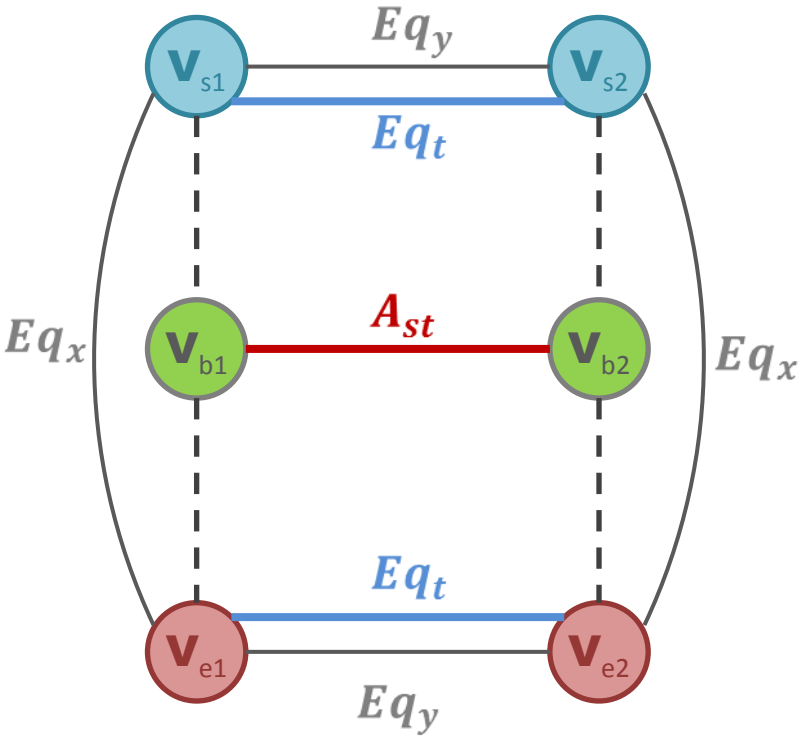


$E_t \in \{Equal_t\}$

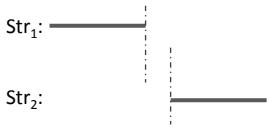
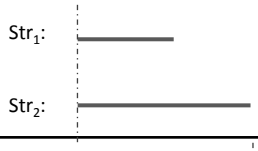
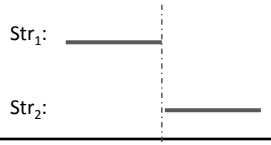
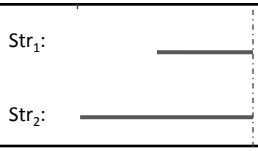
i.e. the edge E_t measures

Graph Representation : Edge

- **Step 3. Allen's relationship[3] between stroke vertices. A_{st}**



$$A_{st} \in \{Allen_x, Allen_y, Allen_t\}$$

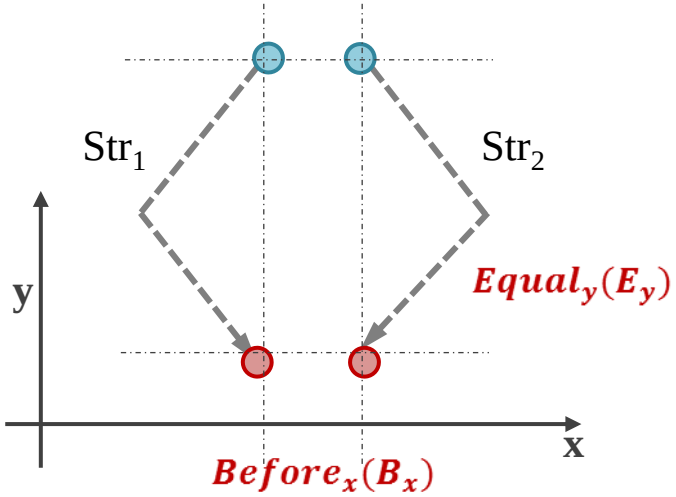
Relation	Example	Relation	Example
Before (B)		During (D)	
Equal (E)		Start (S)	
Meet (M)		Finish (F)	
Overlap (O)			

[3] James F.Allen "Maintaining Knowledge about temporal intervals - CACS", University of Louisiana, (1983).

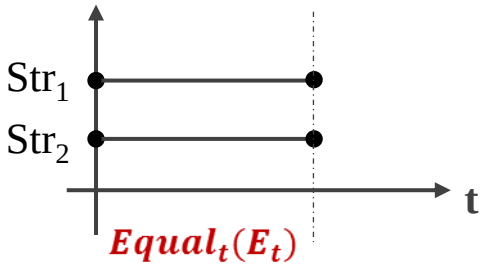
Graph Representation : Edge

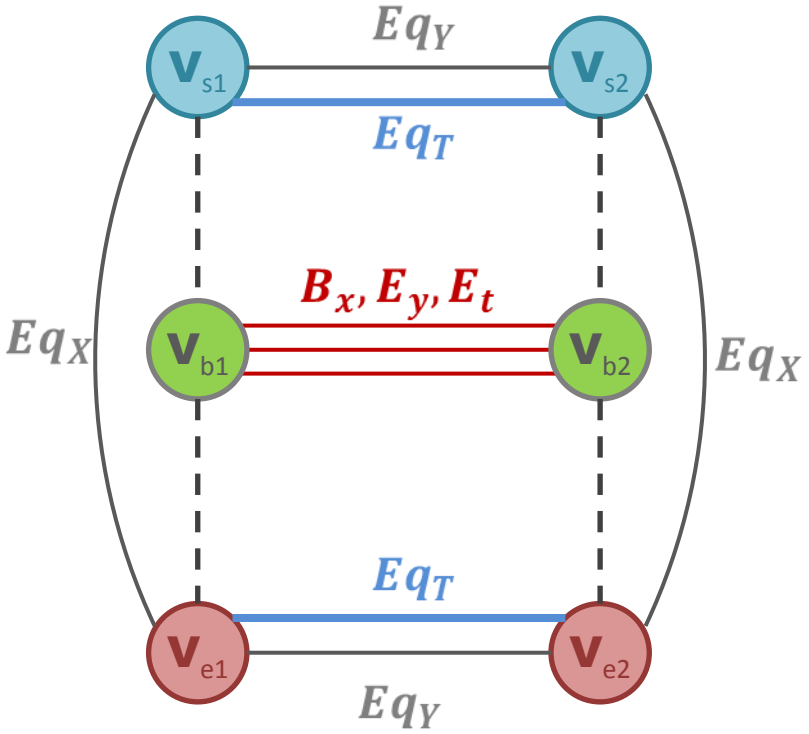
- **Step 3. Allen's relationship[3] between stroke vertices. A_{st}**

  - Spatial domain



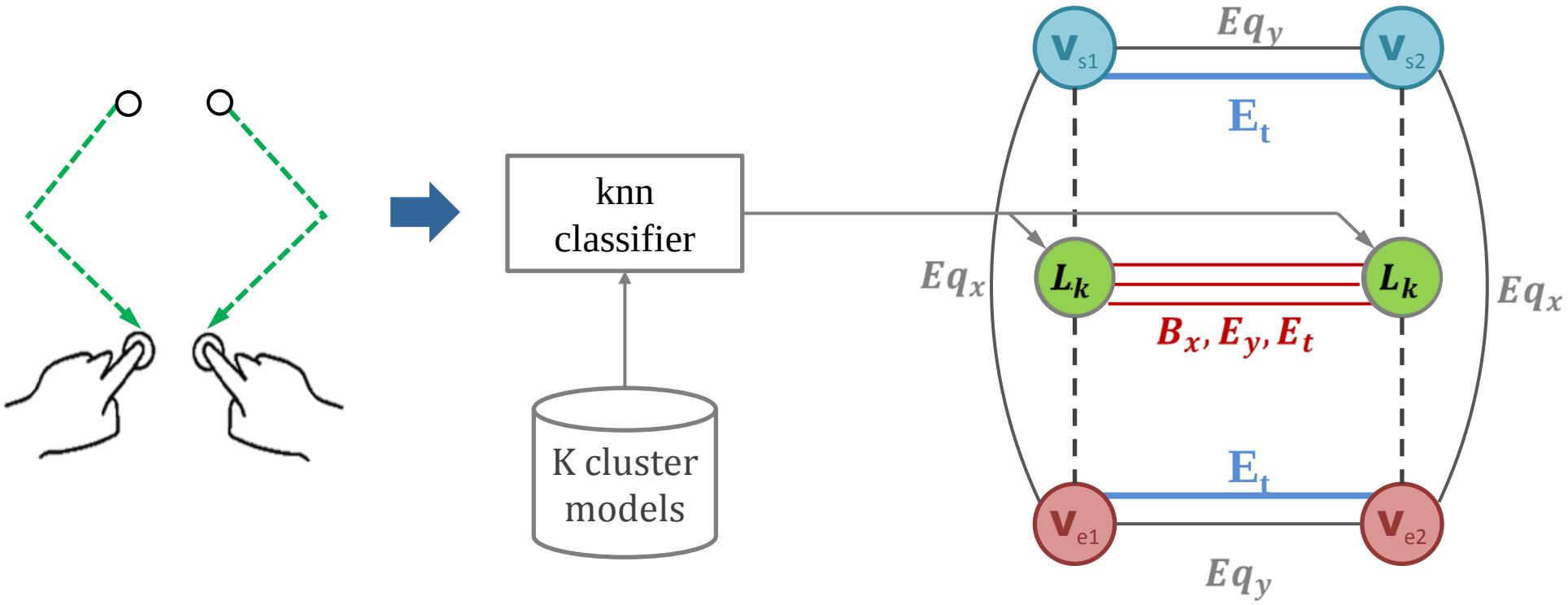
  - Time domain





Graph Representation : Vertex

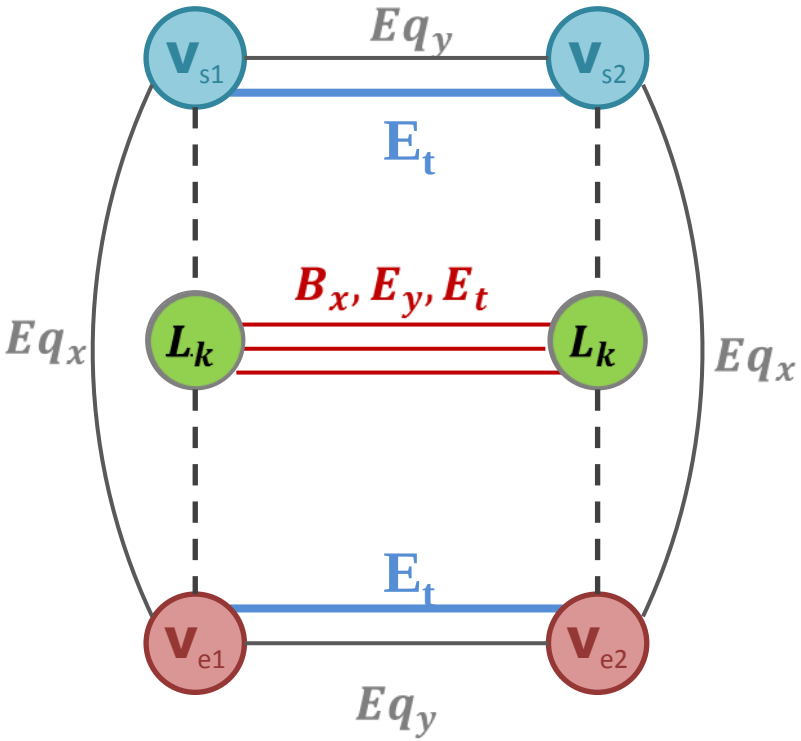
- **Local shape information on stroke vertices.**
  - All the strokes are clustered to K classes using HBF49 feature.
  - Stroke shape label (L_k) is assigned on stroke vertex.



Graph Representation : Graph embedding

- **Embed the graph into a matrix to generate a feature vector[4].**

- Graph domain



- Matrix of frequency

Pattern			
V_{s1}	1	1	4
V_{s2}	1	1	4
L_{k1}	1	1	5
L_{k2}	1	1	5
⋮	⋮	⋮	⋮
V_{e1}	1	1	4
V_{e2}	1	1	4
Eq_x	2	0	2
Eq_y	0	2	2
⋮	⋮	⋮	⋮

- Transform to vector

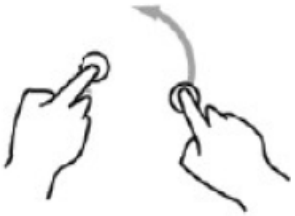
1	1	4	1	…

Classifier
(SVM, knn, etc.)

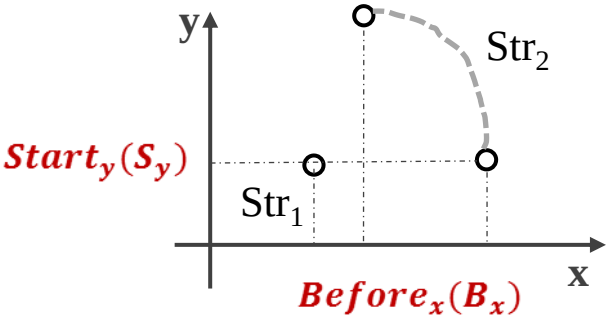
[4] Nicolas Sidere, Pierre Heroux, Jean-Yves Ramel, Vector Representation of Graphs : Application to the Classification of Symbols and Letters, 10th International Conference on Document Analysis and Recognition, ICDAR '09. P 681-685, (2009)

Graph Representation : another example

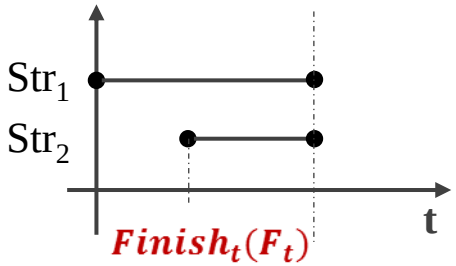
- Another example of an ***anchor rotate*** gesture.
  - ***Anchor rotate***

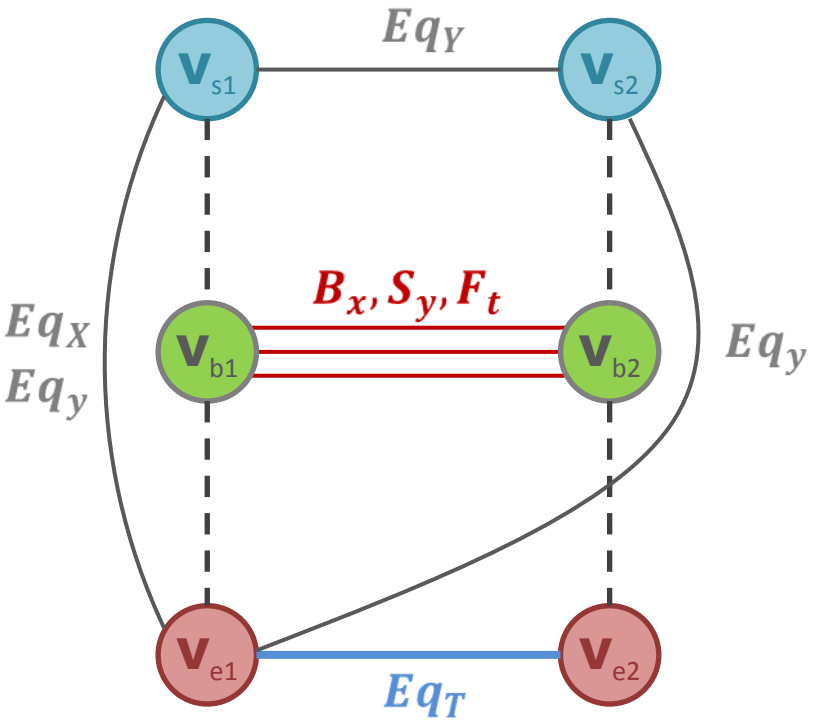


  - Spatial domain



  - Time domain





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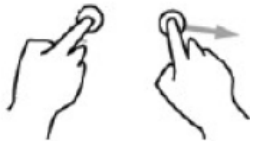
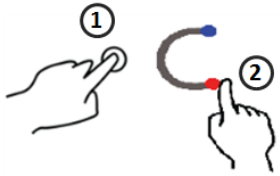
Multi-touch gesture dataset

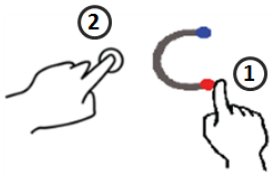
- 10 writers, 10 times each gesture, 18 classes, 1800 samples in total.


Anchor rotate


Achor scale

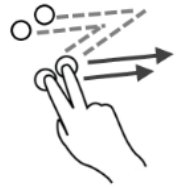


Command C-1

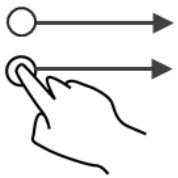


Command C-2

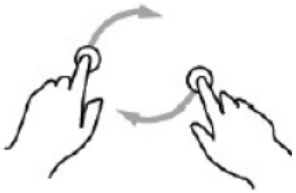

Command X


Erase

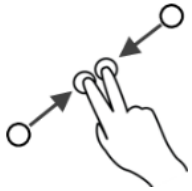

Flick


Flick-twice

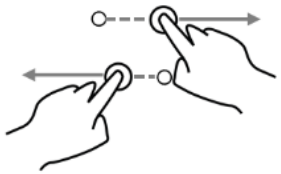

Ring

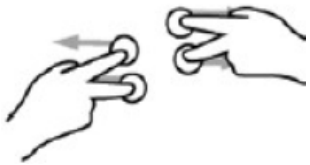

Rotate

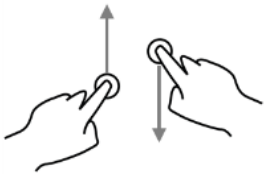

Scale


Pinch


Scroll


Split with 2 fingers


Split with 4 fingers


Switch


Tap


Double tap

Experimentation

Experimental design : comparison of 3 methods

- HBF49 : Traditional on-line feature based method.
- Graph : Feature vector by graph embedding.
- Graph + HBF49 : Concatenate the HBF49 feature vector after graph embedding vector.

Classifier

- SVM with default parameters.

Cross validation

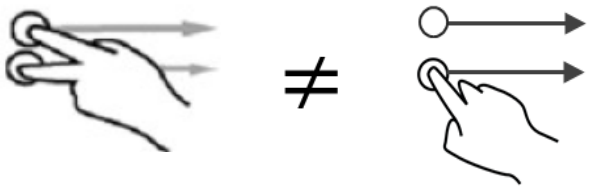
- 5 fold cross validation, writer-independent (WI).

Experimentation

- Result of the experiment

Method	Recognition rate (%)	Std. Deviation
HBF49	90.44	0.034
Graph	92.56	0.013
Graph + HBF49	**94.50**	0.020

- Our graph modeling method has the ability to distinguish the gestures from their temporal information



- Flick
- Flick twice

Conclusion

- Our graph modeling strategy has the ability to deal with more complex multi-touch gesture.

Graph modeling for multi-touch gesture
✔ Shape information
✔ Spatial relationship between strokes
✔ Temporal relationship between strokes

- Perspective
  - Quantify the relationship between strokes instead of using Allen's discrete labels.

Thanks

Welcome questions!

A graph modeling strategy for multi-touch handwritten gesture recognition

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Eric Anquetil, Christian Viard-Gaudin, Harold Mouchère

14th International Conference on Frontiers in Handwriting Recognition
Greece, 2 September 2014

intuidoc
intuitive user-interaction for document

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