

Visual Similarity in Sign Language

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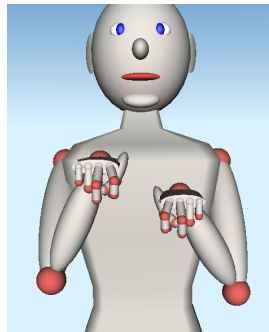
Introduction

- **Sign language** — language of deaf
 - Fully represented by **3D motion** of hands, body and mimics
 - No standardized/natural written form
 - Several notation systems are used
- Motivation — computer **sign language dictionary** able to
 - show the most similar sign for the selected one
 - search for signs according to **sign fragments**
 - ... target users: **a sign language learners**
- **Goal**: an algorithm evaluating **visual similarity** between two signs
 - **independent** of the notation system used
 - **independent** of the language (ASL, Czech Sign Language, etc.)

Minimal pairs

Sign characteristics

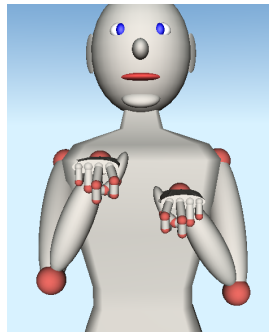
- place (of signing)
- handshape
- palm orientation
- metacarpus orientation
- action/motion (change of place, handshape, ...)



Minimal pairs

Sign characteristics

- place (of signing)
- handshape
- palm orientation
- metacarpus orientation
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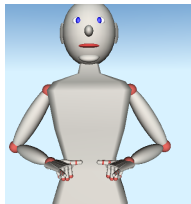


Minimal pair

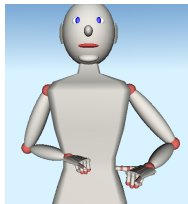
- pair of **similar** signs differing in one characteristic
- created by a deaf
- **Goal**: recognize minimal pair as **the best match**

Examples of visually similar signs (in Czech Sign Language)

Sign DIRECTOR



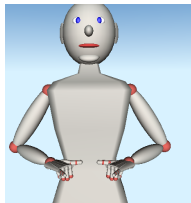
Initial position



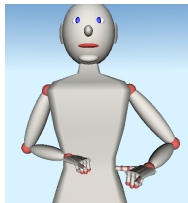
Terminal position

Examples of visually similar signs (in Czech Sign Language)

Sign DIRECTOR

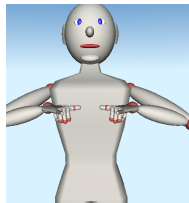


Initial position

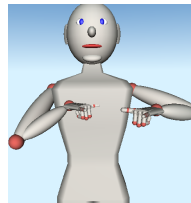


Terminal position

Sign SPORT



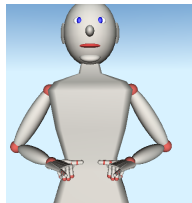
Initial position



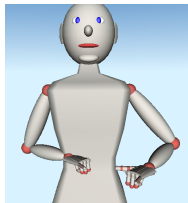
Terminal position

Examples of visually similar signs (in Czech Sign Language)

Sign DIRECTOR

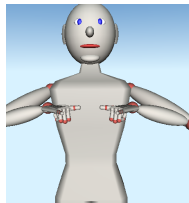


Initial position

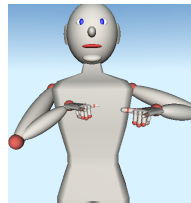


Terminal position

Sign SPORT

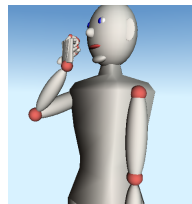


Initial position

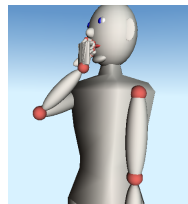


Terminal position

Sign TEETH



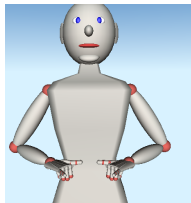
Initial position



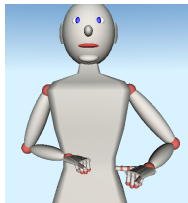
Terminal position

Examples of visually similar signs (in Czech Sign Language)

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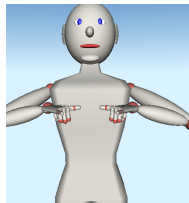


Initial position

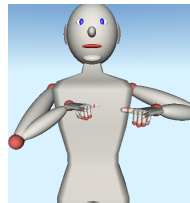


Terminal position

Sign SPORT



Initial position

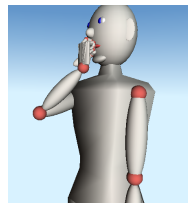


Terminal position

Sign TEETH

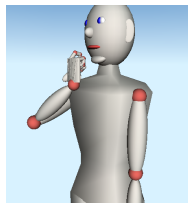


Initial position

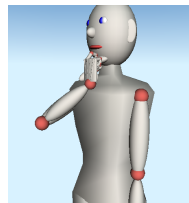


Terminal position

Sign EGG



Initial position



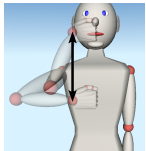
Terminal position

Similarity of the static postures

- based on the sign **geometric appearance** only
- similarity of the static postures evaluated using **criteria**

Similarity of the static postures

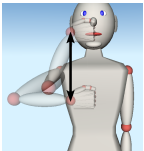
- based on the sign **geometric appearance** only
- similarity of the static postures evaluated using **criteria**
 - wrists distance (a),



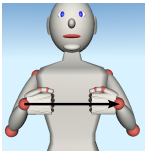
(a)

Similarity of the static postures

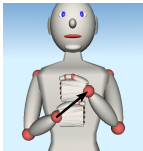
- based on the sign **geometric appearance** only
- similarity of the static postures evaluated using **criteria**
 - wrists distance (a),
 - mutual position of wrists (b), (c),



(a)



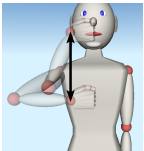
(b)



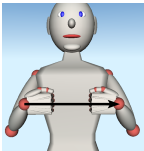
(c)

Similarity of the static postures

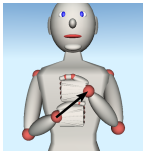
- based on the sign **geometric appearance** only
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 - wrists distance (a),
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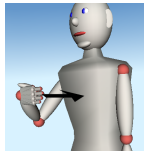
(a)



(b)



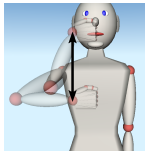
(c)



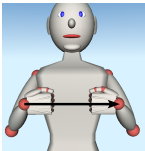
(d)

Similarity of the static postures

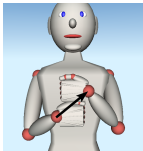
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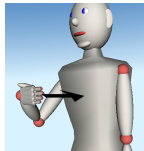
(a)



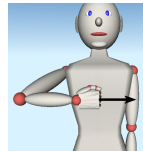
(b)



(c)



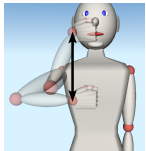
(d)



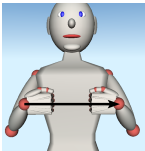
(e)

Similarity of the static postures

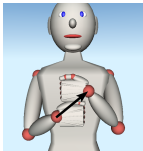
- based on the sign **geometric appearance** only
- similarity of the static postures evaluated using **criteria**
 - wrists distance (a),
 - mutual position of wrists (b), (c),
 - palm orientation (d),
 - metacarpus orientation (e),
 - handshape similarity (positions of the fingertips while wrists are colocated).



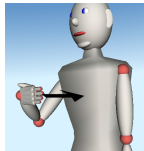
(a)



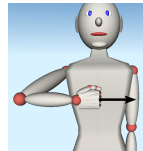
(b)



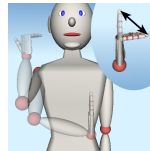
(c)



(d)



(e)

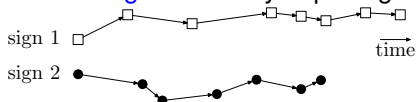


(f)

Similarity of the motions

Motion

- Pairing of **all states** in the shorter of both signs
- **Maximizing** of similarity of pairing

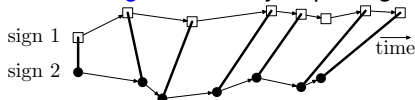


- Penalization of different number of states

Similarity of the motions

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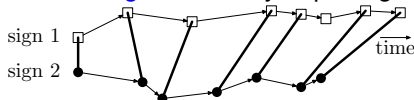


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Similarity of the motions

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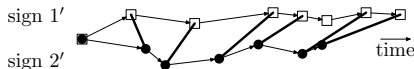


- Penalization of different number of states

Problem: two signs differing in the initial position only

- Idea: compare **initial position** and **motion** apart
- Solution:

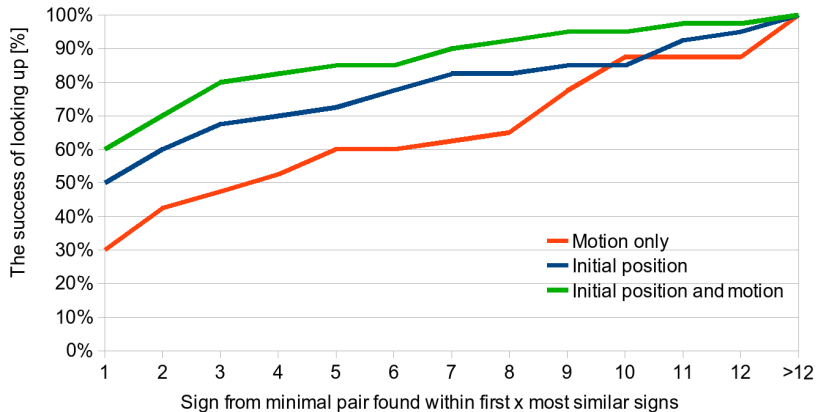
- 1 Evaluate similarity of the initial positions
- 2 Modify signs to have the same initial position
- 3 Evaluate similarity of the motions



Premises

- Czech Sign Language
- Geometric data acquired by **transformation** from sign notation to 3D model
 - each state represents **extreme postures**
 - another notations can be used
- Minimal pairs were used to **evaluate quality** of the proposed metric
 - 40 signs forming 20 minimal pairs

The success of looking up a sign



Future work

- Perform testing on more **extensive database**
- Problem with **inverse motions**
 - Visually dissimilar — left-to-right vs. right-to-left motion
 - Visually similar — clockwise vs. counter-clockwise motion
- Speeding-up computations
 - Estimated **database size** = 5000 signs
 - Similarity of one pair evaluated in 12 ms
- Specifying **sign characteristics** weights
 - User can specify which characteristics he is **interested** in

Conclusion

- ✓ Similarity evaluation algorithm proposal
 - similarity of static postures
 - similarity of motions
- ✓ experimental implementation
 - search for the entered sign
 - find the most similar signs for the currently selected one
- ✓ experimental results on Czech Sign Language:
sign from minimal pair found
 - as the most similar sign in 60 % of cases
 - within the first three most similar signs 80 % of cases