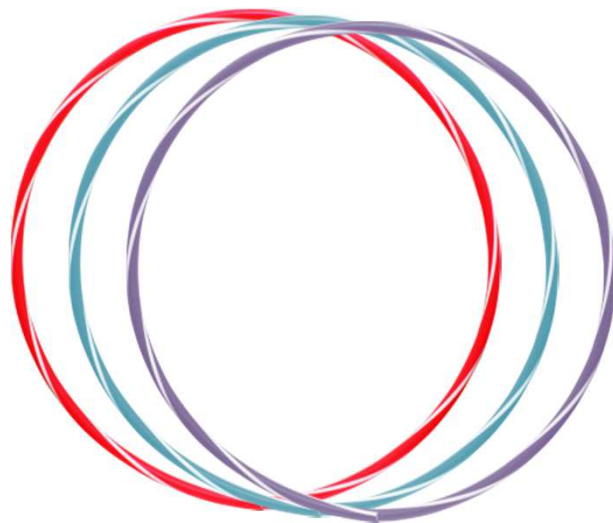
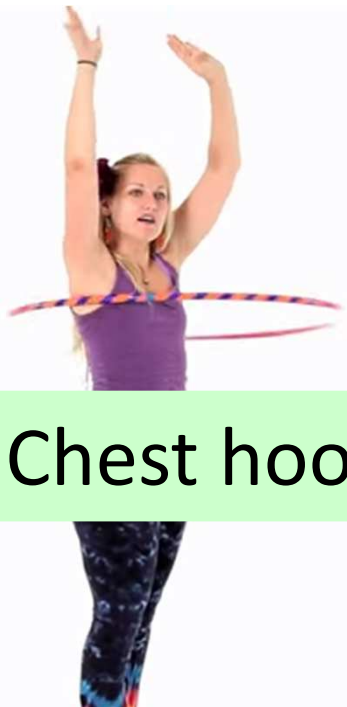


動的時間伸縮法とメタ認知による フラフープ動作習得過程の分析



山岸弥々 加藤礼菜

研究の目的

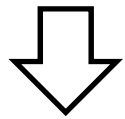
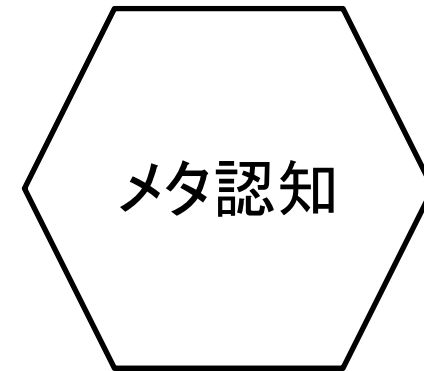


Chest hooping

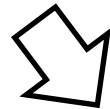
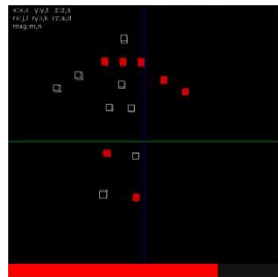
フラフープはダイエットや
健康維持に効果的！



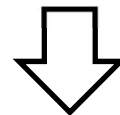
フラフープ動作の習得過程を分析し、
フラフープへの理解を深める！



協調動作



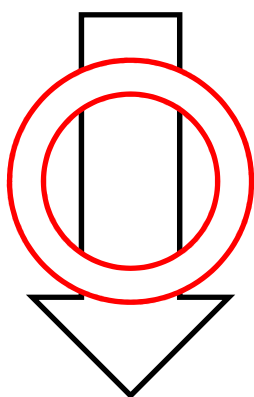
熟達過程



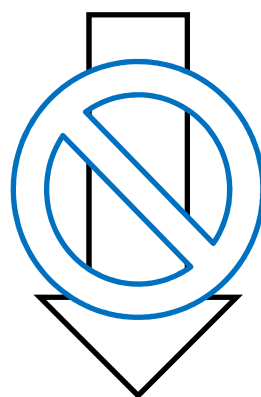
フラフープ動作の理解

基本的なフラフープ動作の難易度

フラフープ未経験者9人にフラフープを行ってもらったところ...



5人



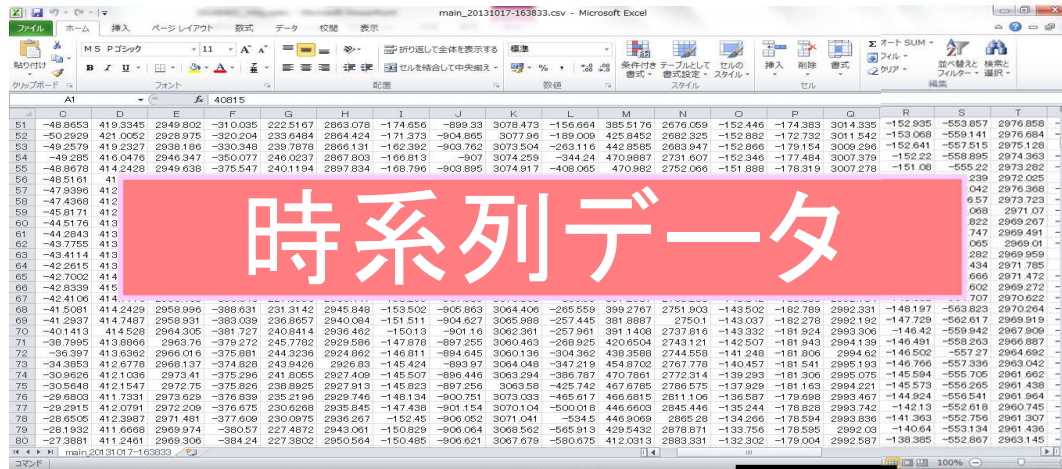
4人



| 被験者 | 計測日数 |
|-----|------|
| A | 3 |
| B | 5 |
| C | 4 |
| D | 3 |

Kinectによるフラフープ動作の計測



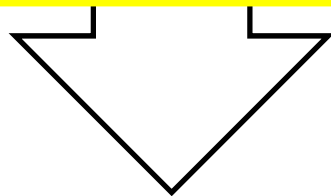


時系列データ

| | A1 | B1 | C1 | D1 | E1 | F1 | G1 | H1 | I1 | J1 | K1 | L1 | M1 | N1 | O1 | P1 | Q1 | R1 | S1 | T1 | |
|----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----|--|
| 51 | -48.8953 | 419.3345 | 2948.802 | -310.035 | 222.5167 | 2863.078 | -174.656 | -899.33 | 3078.473 | -156.664 | 385.8176 | 2676.059 | -152.446 | -174.383 | 3014.335 | -152.835 | -533.857 | 2976.858 | | | |
| 52 | -50.2929 | 421.0052 | 2928.375 | -302.004 | 233.6464 | 2864.424 | -171.373 | -904.895 | 3077.36 | -189.009 | 429.8452 | 2682.325 | -152.892 | -172.332 | 3011.542 | -153.068 | -559.141 | 2976.684 | | | |
| 53 | -49.2579 | 419.2327 | 2938.186 | -330.348 | 239.7878 | 2866.131 | -162.392 | -903.762 | 3074.504 | -263.116 | 442.8585 | 2683.847 | -152.866 | -179.154 | 3008.296 | -152.641 | -557.515 | 2975.128 | | | |
| 54 | -49.285 | 419.0476 | 2946.347 | -350.077 | 246.0237 | 2867.803 | -166.813 | -907 | 3074.259 | -344.24 | 470.9887 | 2731.607 | -152.346 | -177.484 | 3007.379 | -152.22 | -558.895 | 2974.363 | | | |
| 55 | -49.9579 | 414.2428 | 2948.638 | -375.547 | 240.1194 | 2897.634 | -168.796 | -903.895 | 3074.917 | -438.055 | 470.982 | 2752.056 | -151.858 | -178.319 | 3007.278 | -151.00 | -555.22 | 2973.292 | | | |
| 56 | -48.5161 | 41 | | | | | | | | | | | | | | | | 239 | 2972.025 | | |
| 57 | -47.8396 | 412 | | | | | | | | | | | | | | | | 042 | 2976.368 | | |
| 58 | -47.4369 | 412 | | | | | | | | | | | | | | | | 6.57 | 2973.723 | | |
| 59 | -45.8171 | 412 | | | | | | | | | | | | | | | | 068 | 2971.07 | | |
| 60 | -44.5176 | 413 | | | | | | | | | | | | | | | | 822 | 2969.207 | | |
| 61 | -44.2843 | 413 | | | | | | | | | | | | | | | | 747 | 2969.491 | | |
| 62 | -43.7755 | 413 | | | | | | | | | | | | | | | | 065 | 2969.01 | | |
| 63 | -43.4114 | 413 | | | | | | | | | | | | | | | | 282 | 2969.959 | | |
| 64 | -42.2515 | 413 | | | | | | | | | | | | | | | | 434 | 2971.705 | | |
| 65 | -42.7002 | 414 | | | | | | | | | | | | | | | | 666 | 2971.472 | | |
| 66 | -42.8339 | 415 | | | | | | | | | | | | | | | | 602 | 2969.272 | | |
| 67 | -42.4106 | 414 | | | | | | | | | | | | | | | | 707 | 2970.622 | | |
| 68 | -41.5381 | 414.2429 | 2958.996 | -388.631 | 231.3142 | 2945.848 | -153.502 | -905.893 | 3064.406 | -295.559 | 399.2767 | 2751.903 | -143.502 | -182.789 | 2982.331 | -148.197 | -563.823 | 2970.264 | | | |
| 69 | -41.2937 | 414.7487 | 2958.931 | -383.039 | 236.8657 | 2940.084 | -151.511 | -904.627 | 3065.989 | -257.445 | 381.8887 | 2750.1 | -143.037 | -182.278 | 2982.192 | -147.729 | -562.617 | 2969.919 | | | |
| 70 | -40.1413 | 414.528 | 2964.305 | -381.727 | 240.8414 | 2936.482 | -150.13 | -901.16 | 3062.391 | -257.981 | 391.1408 | 2737.816 | -143.332 | -181.824 | 2983.306 | -146.42 | -559.942 | 2967.909 | | | |
| 71 | -39.7895 | 413.8868 | 2963.76 | -379.272 | 245.7782 | 2929.536 | -147.878 | -897.255 | 3060.463 | -268.925 | 420.8504 | 2743.121 | -142.507 | -181.843 | 2984.139 | -145.491 | -558.263 | 2966.887 | | | |
| 72 | -39.397 | 413.6362 | 2966.016 | -375.881 | 244.3236 | 2924.882 | -146.811 | -894.645 | 3060.136 | -304.362 | 438.3588 | 2744.559 | -141.248 | -181.806 | 2984.62 | -145.502 | -557.27 | 2964.682 | | | |
| 73 | -34.3853 | 412.8778 | 2968.137 | -374.828 | 243.8426 | 2926.83 | -145.424 | -893.97 | 3064.048 | -347.219 | 454.8702 | 2767.778 | -140.457 | -181.541 | 2985.193 | -146.766 | -557.336 | 2963.042 | | | |
| 74 | -30.9626 | 412.1036 | 2973.41 | -375.296 | 241.8355 | 2927.409 | -145.507 | -896.448 | 3063.294 | -386.787 | 470.7861 | 2772.314 | -139.293 | -181.306 | 2985.075 | -145.684 | -556.705 | 2961.662 | | | |
| 75 | -30.5648 | 412.1547 | 2972.75 | -375.826 | 238.8925 | 2927.913 | -145.823 | -897.256 | 3063.58 | -425.742 | 467.6785 | 2786.575 | -137.929 | -181.163 | 2984.221 | -145.573 | -556.265 | 2961.436 | | | |
| 76 | -29.6803 | 411.7331 | 2973.829 | -376.839 | 235.2196 | 2929.746 | -146.134 | -900.751 | 3073.033 | -465.617 | 466.6815 | 2811.106 | -136.587 | -179.698 | 2983.467 | -144.824 | -556.541 | 2961.964 | | | |
| 77 | -29.2915 | 412.0791 | 2972.209 | -376.675 | 230.6289 | 2935.845 | -147.438 | -901.154 | 3079.104 | -500.018 | 446.6603 | 2845.446 | -135.244 | -178.828 | 2983.742 | -142.13 | -552.618 | 2960.745 | | | |
| 78 | -28.6500 | 412.3987 | 2971.481 | -377.609 | 230.0975 | 2936.267 | -152.45 | -906.062 | 3071.041 | -534.5 | 446.9069 | 2895.29 | -134.266 | -178.594 | 2983.836 | -141.363 | -552.750 | 2961.307 | | | |
| 79 | -28.1932 | 411.6008 | 2968.974 | -380.57 | 227.4872 | 2943.061 | -150.829 | -906.064 | 3068.562 | -565.913 | 429.5432 | 2878.871 | -133.756 | -178.595 | 2982.03 | -140.64 | -553.134 | 2961.436 | | | |
| 80 | -27.3881 | 411.2461 | 2968.306 | -384.24 | 227.3802 | 2950.564 | -150.485 | -906.621 | 3067.679 | -580.675 | 412.0313 | 2863.331 | -132.302 | -179.004 | 2982.567 | -138.385 | -552.867 | 2963.145 | | | |

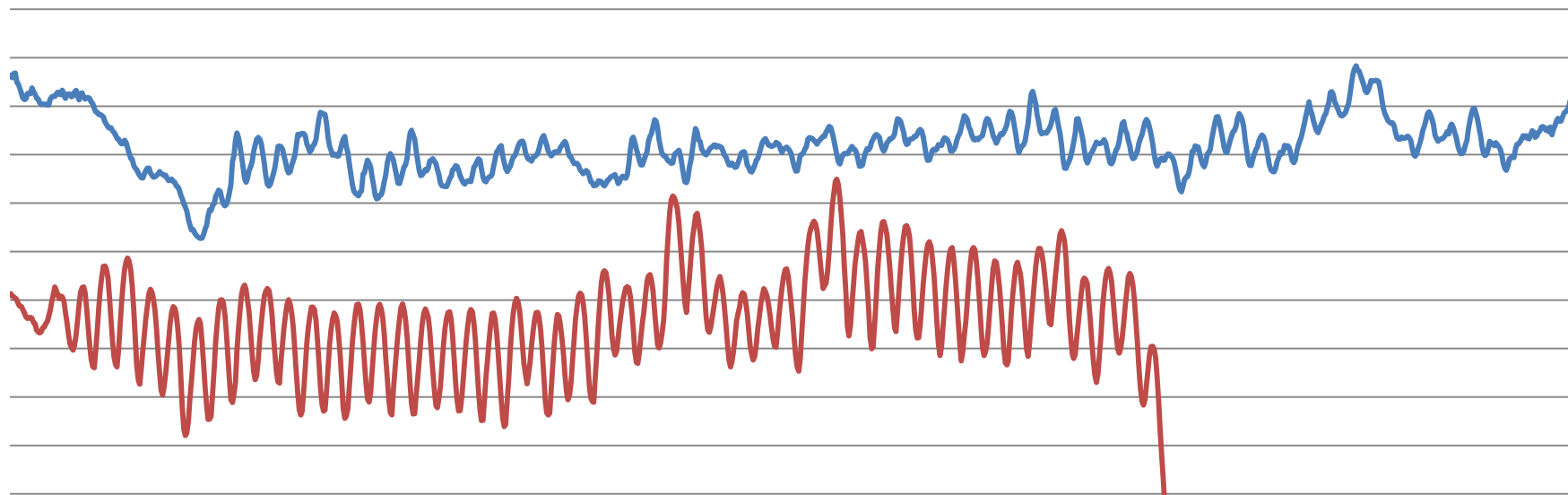


各試行の非類似度を比較



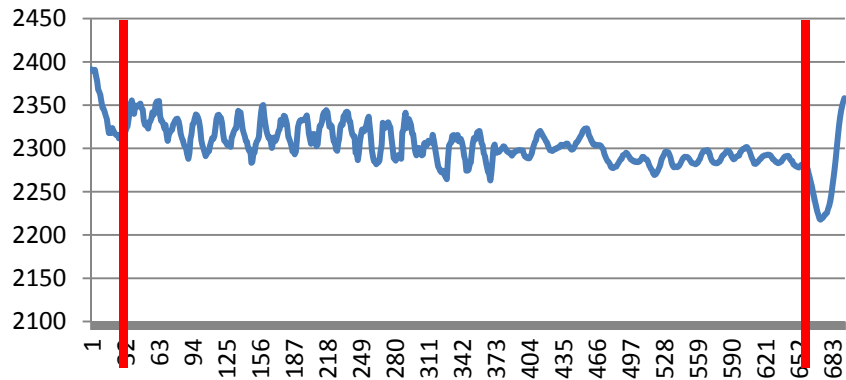
非類似度の変化が著しかったところを
ブレイクスルーとする

動的時間伸縮法 (DTW) について

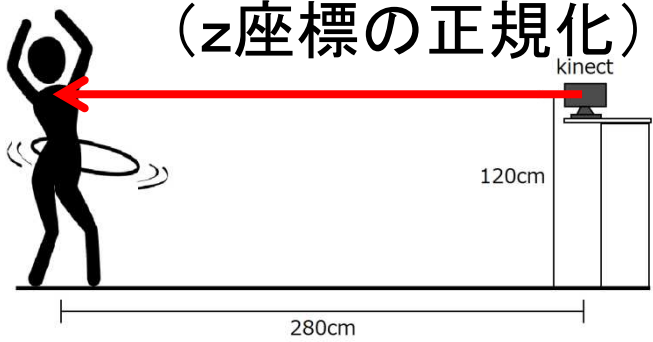
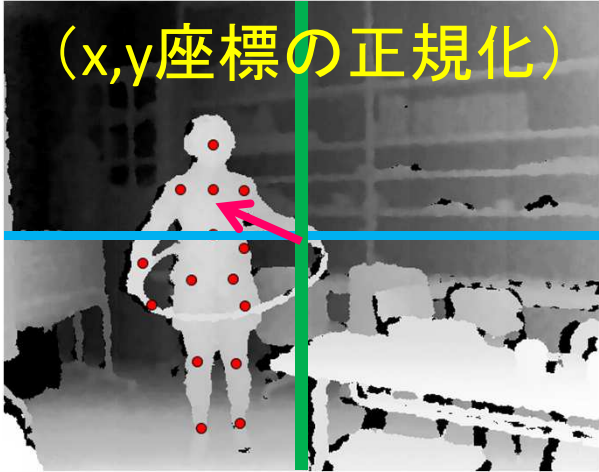


DTWは長さの異なる2つの時系列の
(非)類似度を求める手法である

1. ノイズの除去



2. 座標合わせ



被験者Aの熟達過程における ブレイクスルーの検出結果

非類似度行列

| | 試行1 | 試行2 | 試行3 | 試行4 | 試行5 | 試行6 | 試行7 | 試行8 | 試行9 | 試行10 | 試行11 | 試行12 |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 試行1 | 0.00 | 75.66 | 58.82 | 32.75 | 153.28 | 211.54 | 146.63 | 144.61 | 94.50 | 95.92 | 144.72 | 84.33 |
| 試行2 | 75.66 | 0.00 | 37.16 | 48.03 | 207.01 | 393.57 | 274.04 | 50.79 | 51.74 | 34.54 | 64.64 | 43.95 |
| 試行3 | 58.82 | 37.16 | 0.00 | 35.00 | 100.97 | 260.78 | 155.54 | 116.30 | 58.14 | 83.97 | 128.73 | 48.32 |
| 試行4 | 32.75 | 48.03 | 35.00 | 0.00 | 140.99 | 252.96 | 170.56 | 114.97 | 102.70 | 83.71 | 118.17 | 91.44 |
| 試行5 | 153.28 | 207.01 | 100.97 | 140.99 | 0.00 | 120.33 | 37.63 | 322.81 | 317.94 | 300.28 | 338.50 | 304.69 |
| 試行6 | 211.54 | 393.57 | 260.78 | 252.96 | 120.33 | 0.00 | 50.78 | 472.08 | 451.55 | 436.52 | 478.04 | 441.47 |
| 試行7 | 146.63 | 274.04 | 155.54 | 170.56 | 37.63 | 50.78 | 0.00 | 391.13 | 326.75 | 340.42 | 398.99 | 308.05 |
| 試行8 | 144.61 | 50.79 | 116.30 | 114.97 | 322.81 | 472.08 | 391.13 | 0.00 | 10.30 | 10.51 | 8.28 | 15.65 |
| 試行9 | 94.50 | 51.74 | 58.14 | 102.70 | 317.94 | 451.55 | 326.75 | 10.30 | 0.00 | 8.43 | 10.09 | 8.50 |
| 試行10 | 95.92 | 34.54 | 83.97 | 83.71 | 300.28 | 436.52 | 340.42 | 10.51 | 8.43 | 0.00 | 10.34 | 12.11 |
| 試行11 | 144.72 | 64.64 | 128.73 | 118.17 | 338.50 | 478.04 | 398.99 | 8.28 | 10.09 | 10.34 | 0.00 | 17.80 |
| 試行12 | 84.33 | 43.95 | 48.32 | 91.44 | 304.69 | 441.47 | 308.05 | 15.65 | 8.50 | 12.11 | 17.80 | 0.00 |

被験者B

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

被験者C

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

被験者D

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

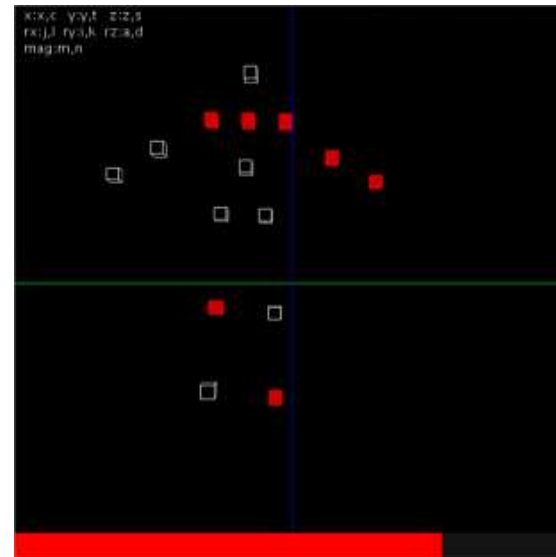
被験者B

被験者C

被験者D

時系列データ

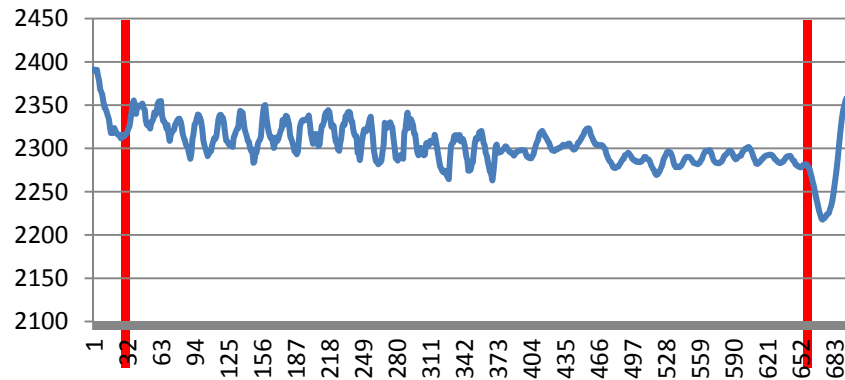
| | A1 | B1 | C1 | D1 | E1 | F1 | G1 | H1 | I1 | J1 | K1 | L1 | M1 | N1 | O1 | P1 | Q1 | R1 | S1 | T1 |
|----|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----|----------|----------|
| 51 | -48.8003 | 419.3344 | | | | | | | | | | | | | | | | | | 2976.858 |
| 52 | -50.2929 | 421.0061 | | | | | | | | | | | | | | | | | | 2976.884 |
| 53 | -46.2578 | 418.2392 | | | | | | | | | | | | | | | | | | 2975.128 |
| 54 | -49.285 | 419.0477 | | | | | | | | | | | | | | | | | | 2974.393 |
| 55 | -46.9678 | 414.2426 | | | | | | | | | | | | | | | | | | 2973.292 |
| 56 | -46.5161 | 413.2005 | | | | | | | | | | | | | | | | | | 2972.025 |
| 57 | -47.3996 | 412.2299 | | | | | | | | | | | | | | | | | | 2976.398 |
| 58 | -47.4269 | 412.3422 | | | | | | | | | | | | | | | | | | 2975.729 |
| 59 | -45.8171 | 412.8922 | | | | | | | | | | | | | | | | | | 2971.07 |
| 60 | -44.5176 | 413.6912 | | | | | | | | | | | | | | | | | | 2969.267 |
| 61 | -44.2843 | 413.1138 | | | | | | | | | | | | | | | | | | 2968.491 |
| 62 | -42.7785 | 413.0929 | 2948.285 | -462.413 | 195.1705 | 2975.139 | -170.996 | -91.1236 | 3070.299 | -316.434 | 408.9995 | 2948.469 | -149.193 | -181.857 | 2986.104 | -153.577 | -395.080 | | 2969.01 | |
| 63 | -43.4114 | 413.0737 | 2949.994 | -403.463 | 193.3791 | 2975.067 | -172.504 | -913.814 | 3076.378 | -447.891 | 439.6766 | 2940.629 | -147.172 | -183.406 | 2996.223 | -151.8 | -504.282 | | 2969.959 | |
| 64 | -42.2615 | 413.5521 | 2950.212 | -403.384 | 193.3895 | 2974.397 | -168.832 | -916.071 | 3072.239 | -414.421 | 434.9452 | 2927.004 | -149.895 | -183.184 | 2990.942 | -150.225 | -564.434 | | 2971.795 | |
| 65 | -42.7002 | 414.1378 | 2951.224 | -401.527 | 192.111 | 2979.6 | -159.083 | -906.493 | 3077.479 | -390.845 | 419.2519 | 2910.066 | -144.529 | -182.995 | 2992.824 | -149.481 | -504.696 | | 2971.472 | |
| 66 | -42.8339 | 415.0762 | 2953.07 | -401.435 | 194.2984 | 2977.633 | -152.813 | -905.968 | 3067.044 | -333.955 | 413.1361 | 2783.221 | -144.786 | -183.548 | 2991.901 | -149.606 | -505.602 | | 2969.272 | |
| 67 | -42.4106 | 414.7719 | 2956.468 | -399.049 | 221.6958 | 2986.447 | -159.295 | -907.935 | 3070.909 | -309.59 | 391.2991 | 2769.233 | -143.842 | -183.683 | 2992.134 | -149.692 | -564.707 | | 2970.622 | |
| 68 | -41.5081 | 414.2429 | 2959.899 | -388.631 | 231.2142 | 2945.848 | -153.502 | -906.863 | 3064.406 | -285.559 | 399.2977 | 2751.903 | -143.502 | -182.789 | 2992.331 | -149.197 | -503.823 | | 2970.264 | |
| 69 | -41.2837 | 414.7467 | 2958.931 | -383.039 | 236.6657 | 2940.084 | -151.511 | -904.627 | 3065.988 | -257.445 | 391.8987 | 2750.1 | -143.037 | -182.278 | 2992.192 | -147.729 | -562.617 | | 2969.919 | |
| 70 | -40.1413 | 414.529 | 2964.326 | -391.727 | 240.8414 | 2936.462 | -150.13 | -901.16 | 3062.261 | -257.991 | 391.1108 | 2737.816 | -143.332 | -181.924 | 2993.306 | -146.42 | -559.842 | | 2967.906 | |
| 71 | -38.7995 | 413.8866 | 2963.76 | -379.272 | 245.7782 | 2929.586 | -147.878 | -897.235 | 3060.463 | -209.925 | 420.6504 | 2743.121 | -142.507 | -181.943 | 2994.139 | -146.491 | -558.293 | | 2966.897 | |
| 72 | -39.397 | 413.6362 | 2969.016 | -375.981 | 244.3336 | 2924.892 | -146.811 | -894.645 | 3050.136 | -304.362 | 439.3696 | 2744.958 | -141.249 | -181.936 | 2994.62 | -145.502 | -557.27 | | 2964.692 | |
| 73 | -34.3953 | 412.6778 | 2969.137 | -374.828 | 243.9426 | 2926.03 | -145.424 | -893.97 | 3064.049 | -347.219 | 454.9702 | 2767.778 | -140.457 | -181.541 | 2995.193 | -146.766 | -557.336 | | 2963.042 | |
| 74 | -30.9626 | 412.1036 | 2973.41 | -376.296 | 241.8055 | 2927.409 | -145.507 | -894.446 | 3063.294 | -386.797 | 470.7691 | 2772.374 | -139.293 | -181.306 | 2995.076 | -145.594 | -556.705 | | 2961.962 | |
| 75 | -30.5649 | 412.1547 | 2972.75 | -372.826 | 238.6925 | 2927.913 | -145.623 | -897.256 | 3063.59 | -425.742 | 467.795 | 2769.575 | -137.929 | -181.163 | 2994.251 | -145.579 | -556.265 | | 2961.436 | |
| 76 | -29.8903 | 411.7391 | 2973.629 | -376.899 | 235.2196 | 2929.746 | -148.194 | -900.751 | 3073.033 | -405.617 | 466.6815 | 2811.106 | -136.597 | -179.698 | 2993.497 | -144.824 | -556.541 | | 2961.994 | |
| 77 | -29.2915 | 412.0791 | 2972.329 | -376.075 | 230.6998 | 2938.846 | -147.438 | -901.154 | 3070.104 | -500.018 | 446.6903 | 2845.446 | -135.244 | -179.893 | 2993.742 | -142.13 | -552.618 | | 2960.745 | |
| 78 | -28.8505 | 412.3987 | 2971.491 | -377.609 | 230.0975 | 2938.297 | -152.45 | -906.052 | 3071.041 | -534.5 | 446.9099 | 2865.29 | -134.296 | -178.594 | 2993.836 | -141.363 | -552.756 | | 2961.307 | |
| 79 | -28.1932 | 411.6668 | 2969.974 | -380.57 | 227.4872 | 2943.061 | -150.829 | -905.064 | 3068.562 | -565.913 | 429.9432 | 2878.871 | -133.759 | -178.595 | 2992.38 | -140.64 | -553.134 | | 2961.436 | |
| 80 | -27.3681 | 411.2491 | 2969.306 | -384.24 | 227.2902 | 2950.594 | -150.465 | -906.621 | 3067.679 | -580.675 | 412.0313 | 2863.231 | -132.302 | -179.004 | 2992.587 | -139.395 | -552.967 | | 2963.145 | |



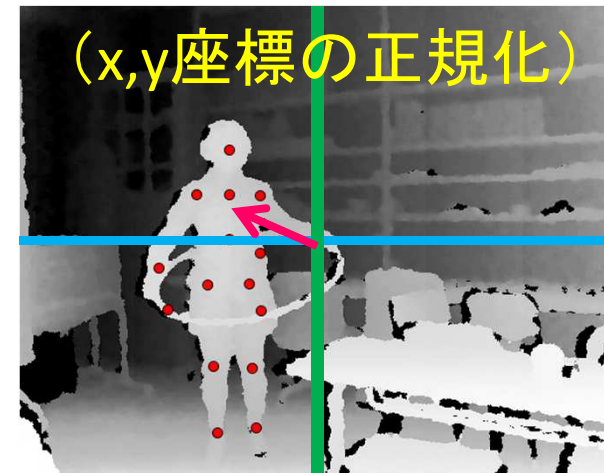
各骨格動作の非類似度を比較

非類似度の値が小さい骨格動作を
協調動作とする

1. ノイズの除去

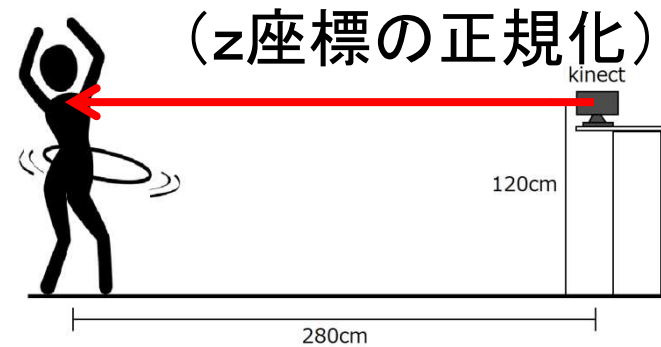


2. 座標合わせ



3. z-スコアへの変換

$$\vec{z}_i = \frac{\vec{u}_i - \bar{u}}{s}$$



協調動作の検出結果(第1試行)

| | 頭 | 左ひじ | 左足 | 左手 | 左腰 | 左ひざ | 左肩 | 首 | 右ひじ | 右足 | 右手 | 右腰 | 右ひざ | 右肩 | 胴 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 頭 | 0.000 | 0.653 | 0.579 | 0.839 | 0.518 | 0.400 | 0.284 | 0.200 | 0.553 | 0.569 | 0.713 | 0.505 | 0.472 | 0.267 | 0.355 |
| 左ひじ | 0.653 | 0.000 | 0.764 | 0.408 | 0.681 | 0.635 | 0.609 | 0.641 | 0.725 | 0.622 | 0.799 | 0.720 | 0.662 | 0.685 | 0.655 |
| 左足 | 0.579 | 0.764 | 0.000 | 0.821 | 0.568 | 0.443 | 0.589 | 0.531 | 0.600 | 0.710 | 0.728 | 0.530 | 0.595 | 0.548 | 0.553 |
| 左手 | 0.839 | 0.408 | 0.821 | 0.000 | 0.860 | 0.804 | 0.837 | 0.831 | 0.854 | 0.808 | 0.866 | 0.858 | 0.850 | 0.853 | 0.832 |
| 左腰 | 0.518 | 0.681 | 0.568 | 0.860 | 0.000 | 0.407 | 0.381 | 0.416 | 0.646 | 0.562 | 0.806 | 0.303 | 0.482 | 0.490 | 0.285 |
| 左ひざ | 0.400 | 0.635 | 0.443 | 0.804 | 0.407 | 0.000 | 0.362 | 0.371 | 0.561 | 0.523 | 0.730 | 0.448 | 0.482 | 0.424 | 0.375 |
| 左肩 | 0.284 | 0.609 | 0.589 | 0.837 | 0.381 | 0.362 | 0.000 | 0.211 | 0.620 | 0.491 | 0.792 | 0.458 | 0.449 | 0.369 | 0.276 |
| 首 | 0.200 | 0.641 | 0.531 | 0.831 | 0.416 | 0.371 | 0.211 | 0.000 | 0.538 | 0.566 | 0.711 | 0.398 | 0.428 | 0.191 | 0.208 |
| 右ひじ | 0.553 | 0.725 | 0.600 | 0.854 | 0.646 | 0.561 | 0.620 | 0.538 | 0.000 | 0.681 | 0.429 | 0.610 | 0.664 | 0.502 | 0.560 |
| 右足 | 0.569 | 0.622 | 0.710 | 0.808 | 0.562 | 0.523 | 0.491 | 0.566 | 0.681 | 0.000 | 0.714 | 0.593 | 0.436 | 0.626 | 0.576 |
| 右手 | 0.713 | 0.799 | 0.728 | 0.866 | 0.806 | 0.730 | 0.792 | 0.711 | 0.429 | 0.714 | 0.000 | 0.779 | 0.785 | 0.678 | 0.750 |
| 右腰 | 0.505 | 0.720 | 0.530 | 0.858 | 0.303 | 0.448 | 0.458 | 0.398 | 0.610 | 0.593 | 0.779 | 0.000 | 0.464 | 0.399 | 0.244 |
| 右ひざ | 0.472 | 0.662 | 0.595 | 0.850 | 0.482 | 0.482 | 0.449 | 0.428 | 0.664 | 0.436 | 0.785 | 0.464 | 0.000 | 0.470 | 0.413 |
| 右肩 | 0.267 | 0.685 | 0.548 | 0.853 | 0.490 | 0.424 | 0.369 | 0.191 | 0.502 | 0.626 | 0.678 | 0.399 | 0.470 | 0.000 | 0.274 |
| 胴 | 0.355 | 0.655 | 0.553 | 0.832 | 0.285 | 0.375 | 0.276 | 0.208 | 0.560 | 0.576 | 0.750 | 0.244 | 0.413 | 0.274 | 0.000 |

非協調動作



協調動作

左手・右手の非類似度が高い
→ほかの骨格動作と協調していない

協調動作の検出結果（最終試行）

| | 頭 | 左ひじ | 左足 | 左手 | 左腰 | 左ひざ | 左肩 | 首 | 右ひじ | 右足 | 右手 | 右腰 | 右ひざ | 右肩 | 胴 |
|-----|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 頭 | 0.000 | 0.616 | 0.729 | 0.801 | 0.671 | 0.705 | 0.283 | 0.269 | 0.627 | 0.760 | 0.728 | 0.714 | 0.667 | 0.364 | 0.552 |
| 左ひじ | 0.616 | 0.000 | 0.853 | 0.321 | 0.640 | 0.827 | 0.504 | 0.495 | 0.801 | 0.804 | 0.651 | 0.712 | 0.794 | 0.549 | 0.476 |
| 左足 | 0.729 | 0.853 | 0.000 | 0.986 | 0.774 | 0.550 | 0.689 | 0.742 | 0.834 | 0.539 | 0.925 | 0.822 | 0.596 | 0.774 | 0.787 |
| 左手 | 0.801 | 0.321 | 0.986 | 0.000 | 0.722 | 0.919 | 0.687 | 0.682 | 1.015 | 0.887 | 0.766 | 0.766 | 0.914 | 0.722 | 0.587 |
| 左腰 | 0.671 | 0.640 | 0.774 | 0.722 | 0.000 | 0.584 | 0.549 | 0.570 | 0.876 | 0.747 | 0.833 | 0.288 | 0.699 | 0.625 | 0.373 |
| 左ひざ | 0.705 | 0.827 | 0.550 | 0.919 | 0.584 | 0.000 | 0.651 | 0.693 | 0.865 | 0.572 | 0.922 | 0.669 | 0.484 | 0.730 | 0.666 |
| 左肩 | 0.283 | 0.504 | 0.689 | 0.687 | 0.549 | 0.651 | 0.000 | 0.178 | 0.595 | 0.654 | 0.671 | 0.614 | 0.696 | 0.372 | 0.392 |
| 首 | 0.269 | 0.495 | 0.742 | 0.682 | 0.570 | 0.693 | 0.178 | 0.000 | 0.643 | 0.712 | 0.690 | 0.623 | 0.696 | 0.227 | 0.383 |
| 右ひじ | 0.627 | 0.801 | 0.834 | 1.015 | 0.876 | 0.865 | 0.595 | 0.643 | 0.000 | 0.817 | 0.581 | 0.882 | 0.923 | 0.749 | 0.759 |
| 右足 | 0.760 | 0.804 | 0.539 | 0.887 | 0.747 | 0.572 | 0.654 | 0.712 | 0.817 | 0.000 | 0.831 | 0.776 | 0.619 | 0.758 | 0.728 |
| 右手 | 0.728 | 0.651 | 0.925 | 0.766 | 0.833 | 0.922 | 0.671 | 0.690 | 0.581 | 0.831 | 0.000 | 0.828 | 0.928 | 0.753 | 0.773 |
| 右腰 | 0.714 | 0.712 | 0.822 | 0.766 | 0.288 | 0.669 | 0.614 | 0.623 | 0.882 | 0.776 | 0.828 | 0.000 | 0.686 | 0.639 | 0.386 |
| 右ひざ | 0.667 | 0.794 | 0.596 | 0.914 | 0.699 | 0.484 | 0.696 | 0.696 | 0.923 | 0.619 | 0.928 | 0.686 | 0.000 | 0.675 | 0.718 |
| 右肩 | 0.364 | 0.549 | 0.774 | 0.722 | 0.625 | 0.730 | 0.372 | 0.227 | 0.749 | 0.758 | 0.753 | 0.639 | 0.675 | 0.000 | 0.427 |
| 胴 | 0.552 | 0.476 | 0.787 | 0.587 | 0.373 | 0.666 | 0.392 | 0.383 | 0.759 | 0.728 | 0.773 | 0.386 | 0.718 | 0.427 | 0.000 |

非協調動作

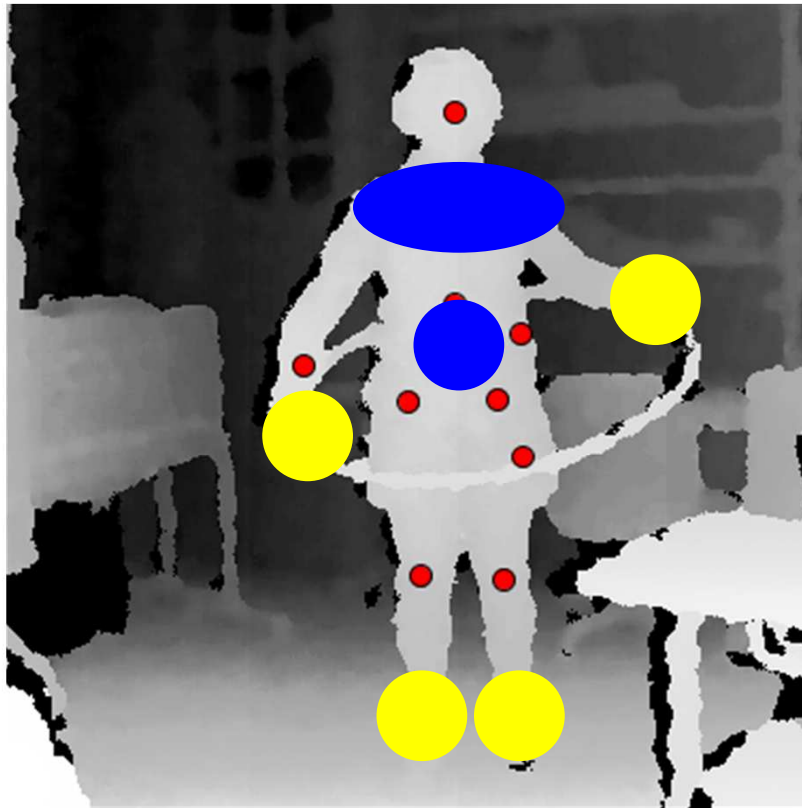


協調動作

両肩・首・胴の動作がほぼ全骨格と類似
→ 4骨格は協調している

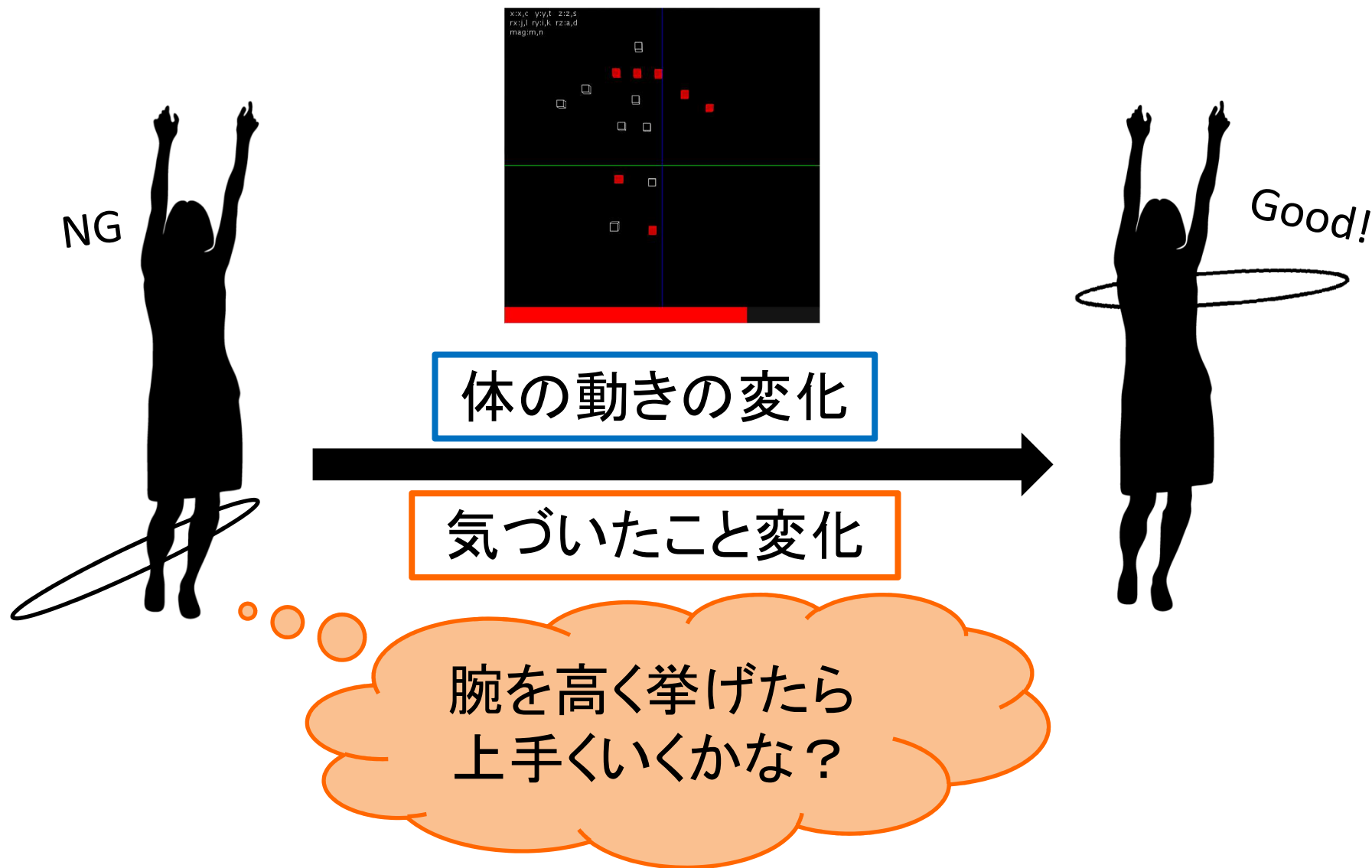
Kinect を用いたフラフープ動作の分析 の考察

効果的にブレイクスルーの検出ができた！

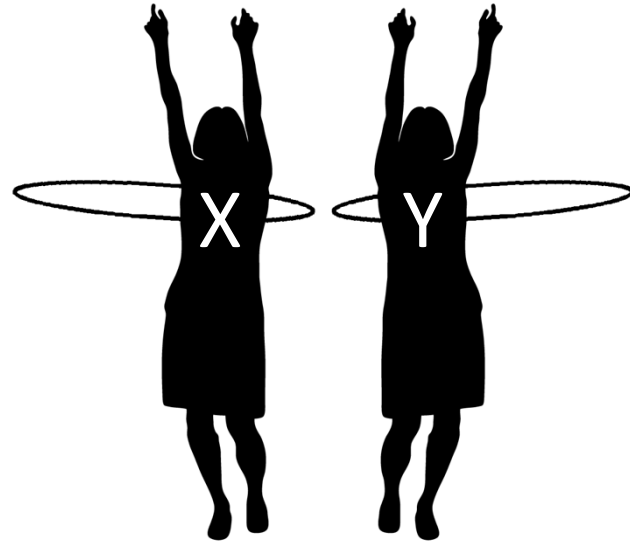


協調動作
胴・両肩・首
⇕
非協調動作
手・足

Chest Hooping 習得過程の分析



Chest Hooping習得実験



- 被験者2名
- 1日20分
- 週2~3回

被験者がChest Hoopingを習得するまで計測



Chest Hoopingの習得 : 10 回以上回せる状態

実験結果

◆ **実験期間** 49 日間(計測は15 日間)

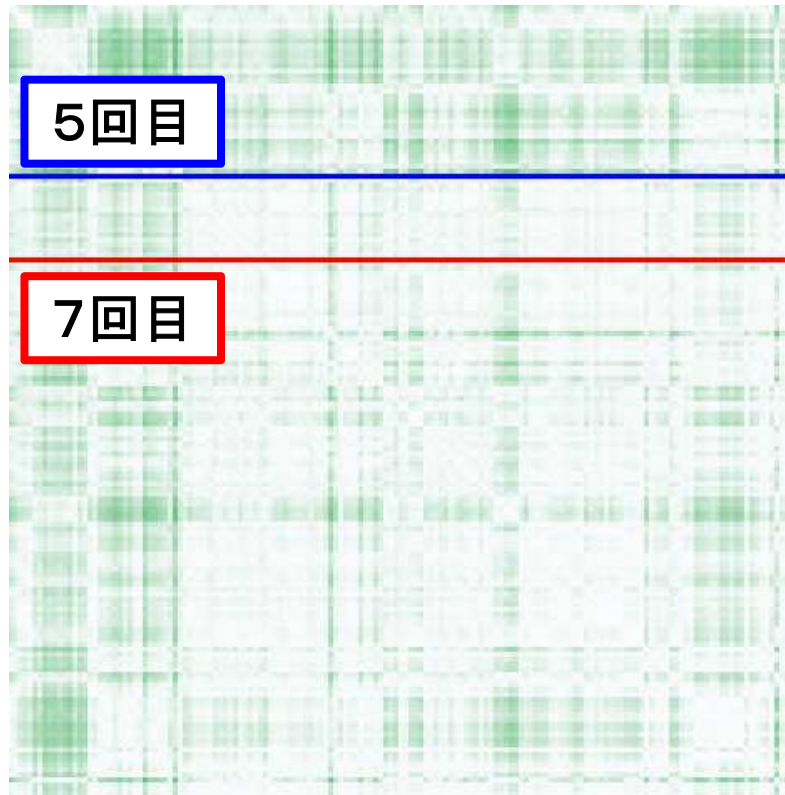
◆ **動作の習得** 被験者X: 実験7回目
被験者Y: 実験12回目

◆ **データ数**

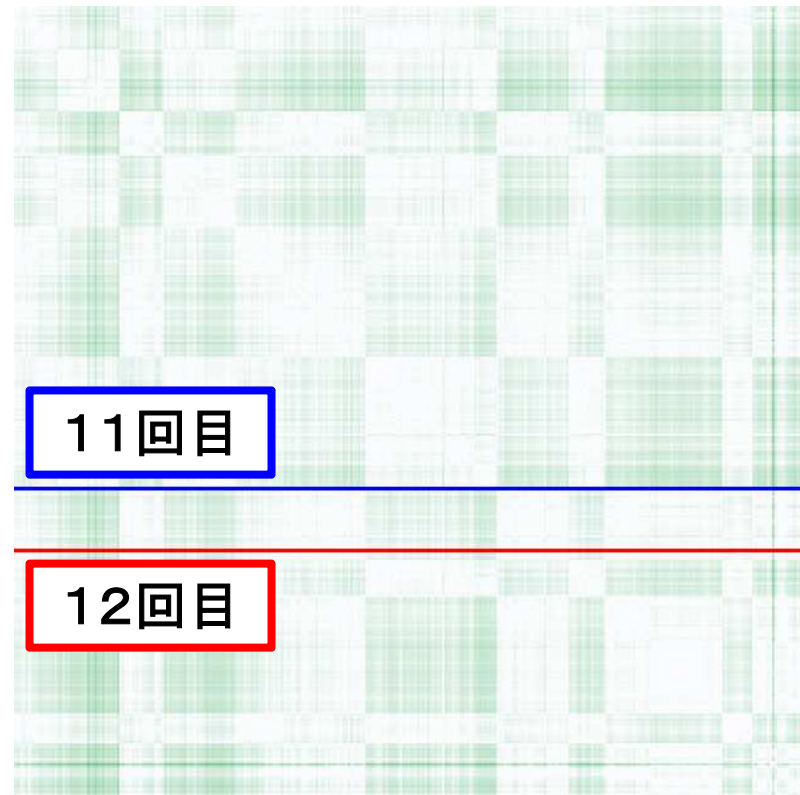
| 被験者 | X | Y |
|------------|-----|-----|
| 計測された試行数 | 218 | 557 |
| 記入したhexの枚数 | 81 | 92 |

DTWによる分析結果

被験者X



被験者Y



身体の動きのブレイクスルーの地点と
Chest Hoopingを取得した地点では差が生じた

気づきの分析：メタ認知



動作を覚える過程の言語化は困難(黙認知)



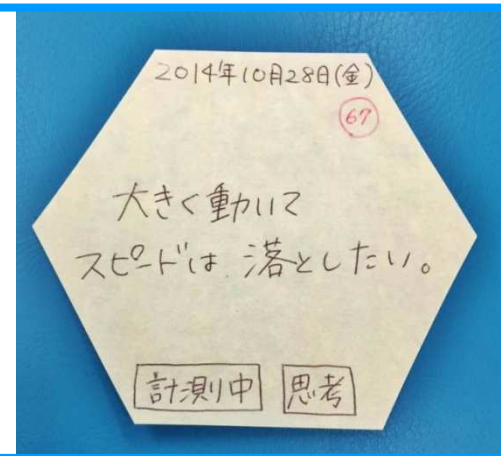
文房具を用いて気づきを言語化する

hexを用いたメタ認知の言語化

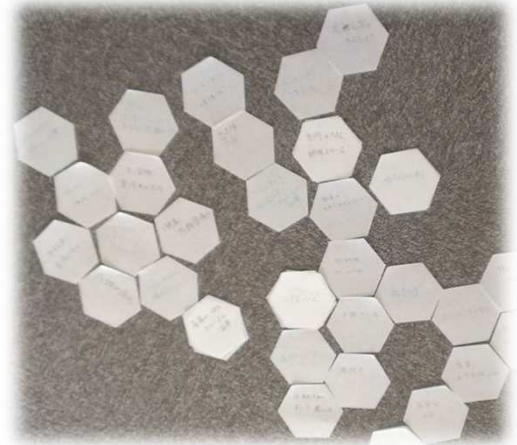
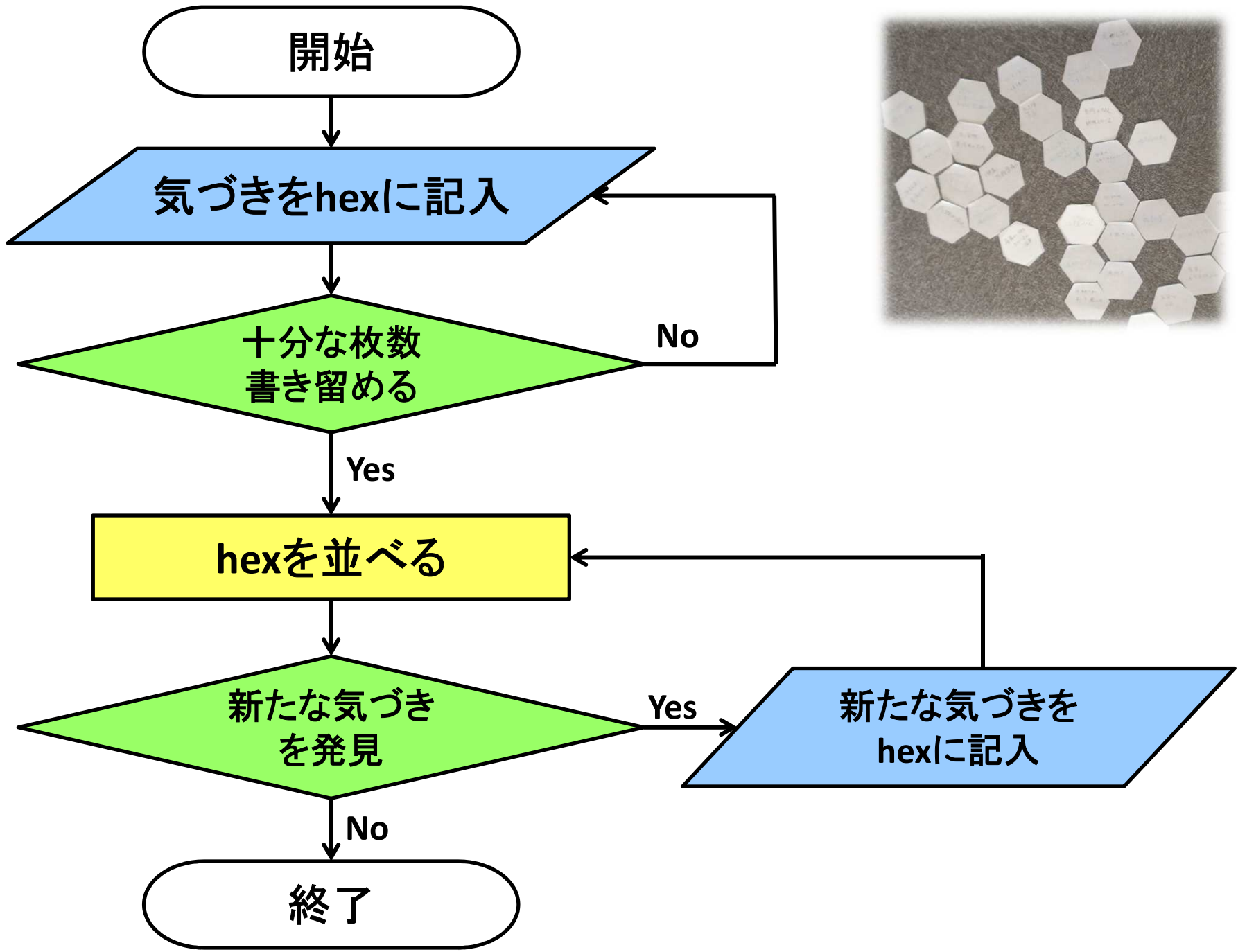


hex = メタ認知的な気づきを
書き留める用紙

1冊60ページ / 一辺45cm / 正六角形

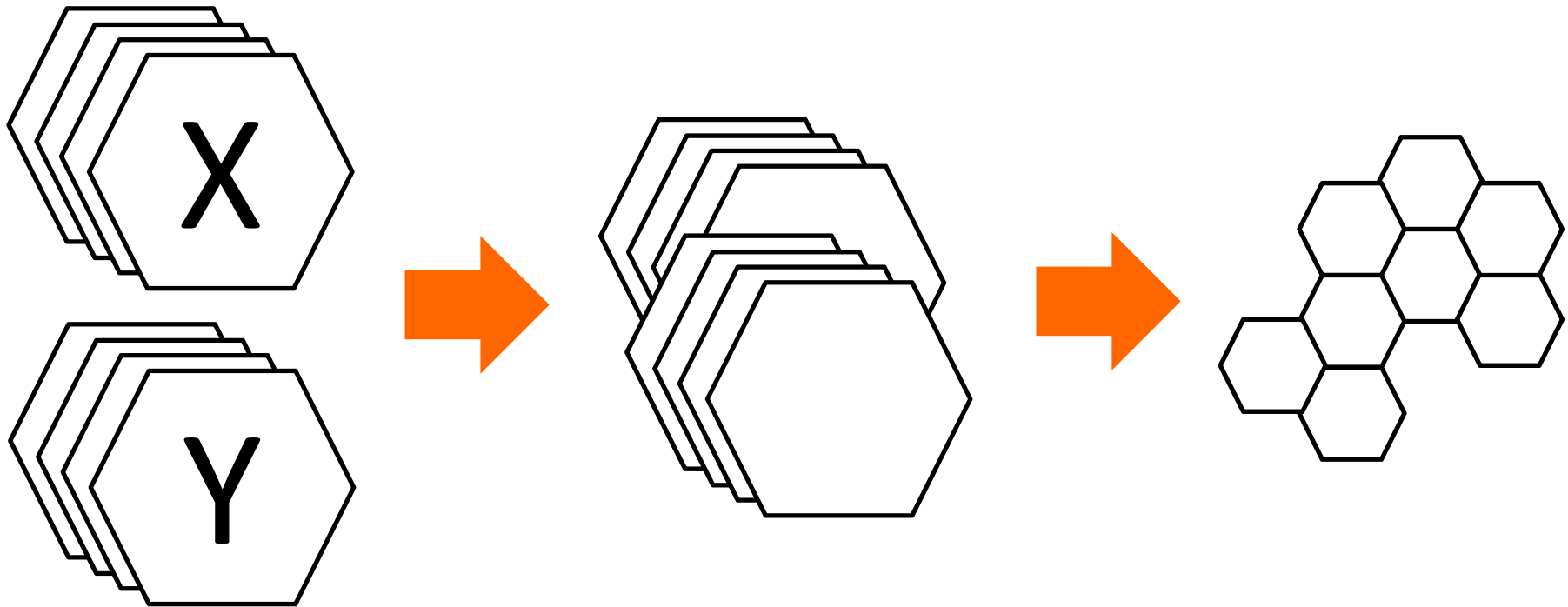


西山武繁, 諏訪正樹, 三浦秀彦, 松原正樹, 佐山由佳: 文房具による身体的メタ認知の促進, 身体知研究会(人工知能学会第2種研究会)SIG-SKL-07-02, pp. 9--13 (2010)



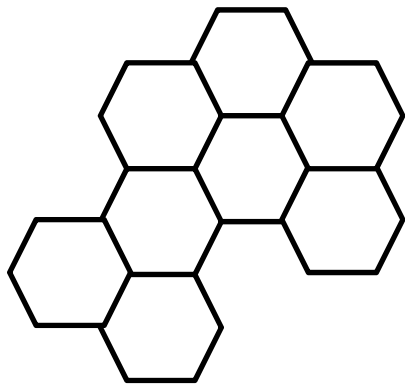
hexの分析

記述したhexがある程度書き溜められた地点で
二人のhexを合わせて、並べる

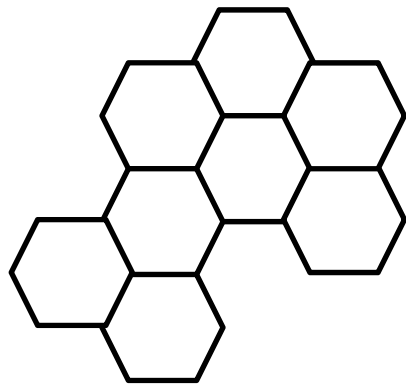


hexの分析

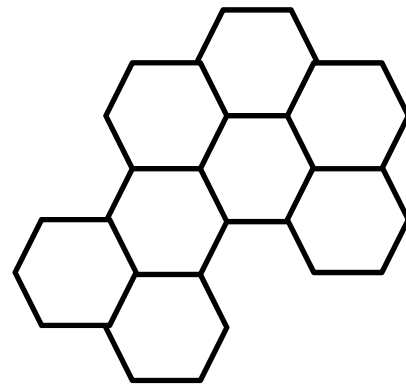
記述したhexがある程度書き溜められた地点で
二人のhexを合わせて、並べる



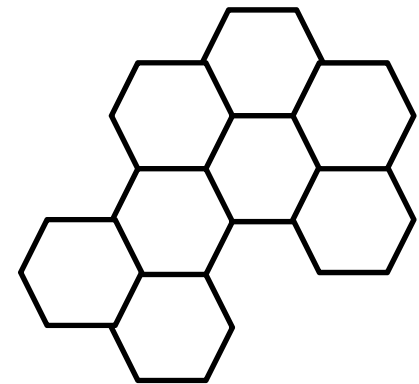
A



B



C



D



頻出語の変遷

hexの記述から動詞・名詞を抽出→頻出語特定

関心のあるトピックの変化

●各部位の動き(A・B)



●最初のタイミング(B・C)



●全身の動き(C・D)



●習得した動き(D)

1.各部位の動き

2.最初のタイミング

3.全身の動き

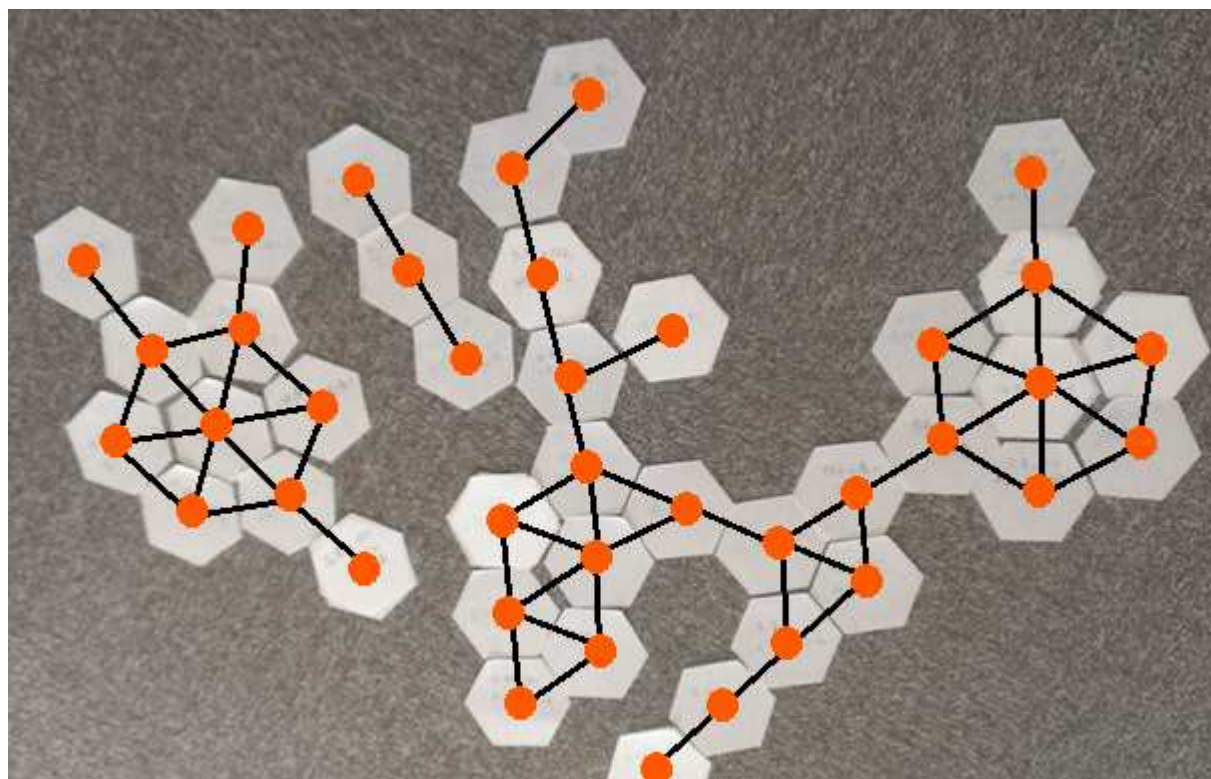
4.習得した動き

| 動詞 | A | B | C | D |
|-----|----|----|----|----|
| 離* | 8 | | | |
| 気付* | 8 | | | |
| 拳* | 6 | 12 | | |
| 当* | 7 | 5 | 10 | |
| 傾い | 16 | 10 | 10 | |
| ずれ | | 10 | | |
| 合* | | 5 | 4 | |
| 押* | | | 2 | 5 |
| 出来* | | | 5 | 3 |
| 続け | | | | 7 |
| 使* | | | | 9 |
| わか* | 8 | 5 | | 13 |
| 保* | 8 | 12 | | 9 |
| 開* | 8 | | 5 | |
| 引く | 16 | | 5 | |
| 上* | 13 | | 14 | 7 |

| 名詞 | A | B | C | D |
|------|----|----|----|----|
| 姿勢 | 7 | 6 | 31 | |
| 腰 | 7 | 32 | | 29 |
| 自分 | 9 | 9 | 31 | |
| 目・目線 | 9 | 9 | | 29 |
| 腕 | 9 | 32 | | 14 |
| 上半身 | 9 | | 31 | 7 |
| 失敗 | 16 | 9 | | |
| 足・脚 | 16 | | 3 | 14 |
| 後ろ | 21 | | 4 | 29 |
| 水平 | 21 | | 31 | 10 |
| 肩 | 32 | 9 | | |
| 状態 | 32 | 9 | 16 | |
| 力 | 32 | | 4 | 29 |
| 今 | 32 | | | 7 |
| 最初 | | 6 | 31 | |
| 全身 | | 9 | | |
| リズム | | 32 | 2 | 10 |
| スピード | | | 16 | 3 |
| 体力 | | | | 7 |

hexのネットワーク分析

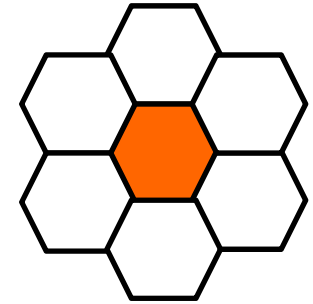
並べられたhex をネットワークと考え、分析する



■ NodeXLを使用

<NodeXL><http://nodexl.codeplex.com/>

次数6のhexのテキスト



| | |
|---|------------------|
| A | 体の動き |
| B | フラフープの動き・体の動き |
| C | 体とフラフープの動きのタイミング |
| D | 体の動き |

Chest Hooping習得までのステップ

体の部位の動き



フラフープの動き



体とフラフープのタイミング

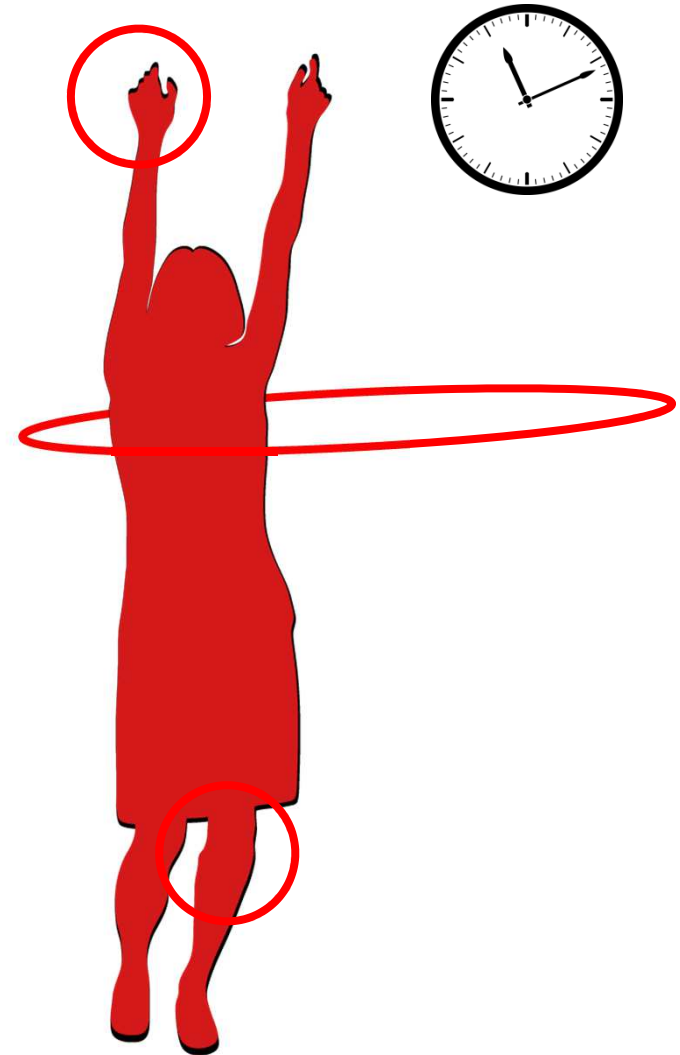


フラフープを動かす

ための体の動き



継続して回すための動き



動作的分析との関連

体の部位の動き



フラフープの動き



体とフラフープのタイミング

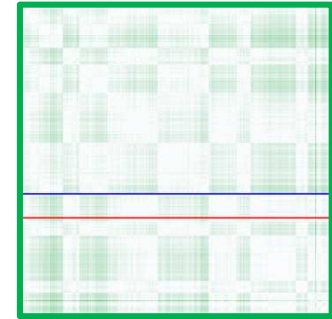


フラフープを動かす

ための体の動き



継続して回すための動き



まとめ

Chest Hoopingにおいて...

身体の動きを習得



体とフラフープの動きの
タイミングを合わせる



Chest Hooping習得！



最後に

◆フラフープ動作

ブレイクスルーと協調動作の検出

◆Chest Hooping

身体知の習得過程のステップの発見

(今後の課題)

フラフープを用いた動作以外でも、同様の過程を経て身体知獲得がされるのかを明らかにする