

# Group 17: Automatic Assessment of Surgical Ergonomics

Boyoung Zhao, Eric Han  
Mentors: Dr. Galaiya, Dr.  
Taylor



**Problem**

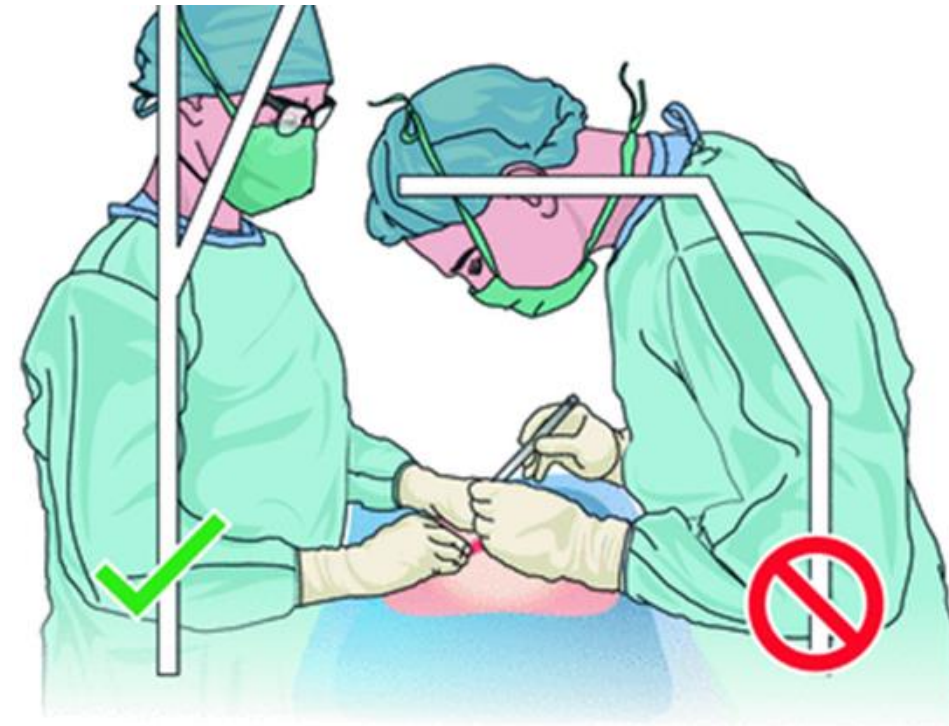
# Ergonomics

Bad Posture

Increased Fatigue

Weight Gain

Musculoskeletal Disorders





**Solution**

# Algorithms Used

## RULA Employee Assessment Worksheet

### A. Arm and Wrist Analysis

#### Step 1: Locate Upper Arm Position:



Step 1a: Adjust...  
If shoulder is raised: +1  
If upper arm is abducted: +1  
If arm is supported or person is leaning: -1

Upper Arm Score

#### Step 2: Locate Lower Arm Position:



Step 2a: Adjust...  
If either arm is working across midline or out to side of body: Add +1

Lower Arm Score

#### Step 3: Locate Wrist Position:



Step 3a: Adjust...  
If wrist is bent from midline: Add +1

Wrist Twist Score

#### Step 4: Wrist Twist:

If wrist is twisted in mid-range: +1  
If wrist is at or near end of range: +2

Wrist Score

#### Step 5: Look-up Posture Score in Table A:

Using values from steps 1-4 above, locate score in Table A

#### Step 6: Add Muscle Use Score

If posture mainly static (i.e. held >1 minute), or if action repeated occurs 4X per minute: +1

Posture Score A

#### Step 7: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0  
If load 4.4 to 22 lbs. (intermittent): +1  
If load 4.4 to 22 lbs. (static or repeated): +2  
If more than 22 lbs. or repeated or shocks: +3

Muscle Use Score

#### Step 8: Find Row in Table C

Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in Table C.

Force / Load Score

Wrist & Arm Score

Task Name:

Date:

### Scores

Table A

| Upper Arm | Lower Arm | Wrist Score |   |   |   |   |   |   |
|-----------|-----------|-------------|---|---|---|---|---|---|
|           |           | 1           | 2 | 3 | 4 |   |   |   |
| 1         | 1         | 1           | 2 | 2 | 2 | 3 | 3 | 3 |
| 1         | 2         | 2           | 2 | 2 | 3 | 3 | 3 | 3 |
| 2         | 1         | 2           | 3 | 3 | 3 | 3 | 4 | 4 |
| 2         | 2         | 3           | 3 | 3 | 3 | 4 | 4 | 4 |
| 3         | 1         | 3           | 3 | 3 | 3 | 4 | 4 | 4 |
| 3         | 2         | 3           | 3 | 3 | 3 | 4 | 4 | 4 |
| 4         | 1         | 4           | 4 | 4 | 4 | 4 | 5 | 5 |
| 4         | 2         | 4           | 4 | 4 | 4 | 4 | 5 | 5 |
| 5         | 1         | 4           | 4 | 4 | 4 | 4 | 5 | 5 |
| 5         | 2         | 4           | 4 | 4 | 4 | 4 | 5 | 5 |
| 6         | 1         | 5           | 5 | 5 | 5 | 5 | 6 | 6 |
| 6         | 2         | 5           | 5 | 5 | 5 | 5 | 6 | 6 |
| 6         | 3         | 6           | 6 | 6 | 6 | 6 | 7 | 7 |
| 6         | 4         | 6           | 6 | 6 | 6 | 6 | 7 | 7 |
| 6         | 5         | 6           | 6 | 6 | 6 | 6 | 7 | 7 |
| 6         | 6         | 6           | 6 | 6 | 6 | 6 | 7 | 7 |
| 6         | 7         | 7           | 7 | 7 | 7 | 7 | 8 | 8 |
| 6         | 8         | 7           | 7 | 7 | 7 | 7 | 8 | 8 |
| 6         | 9         | 8           | 8 | 8 | 8 | 8 | 9 | 9 |
| 6         | 3         | 9           | 9 | 9 | 9 | 9 | 9 | 9 |

Table B

| Upper Arm | Lower Arm | Neck, Trunk, Leg Score |   |   |   |   |   |
|-----------|-----------|------------------------|---|---|---|---|---|
|           |           | 1                      | 2 | 3 | 4 | 5 | 6 |
| 1         | 1         | 1                      | 2 | 3 | 3 | 4 | 5 |
| 1         | 2         | 2                      | 2 | 3 | 3 | 4 | 5 |
| 2         | 1         | 2                      | 2 | 3 | 3 | 4 | 5 |
| 2         | 2         | 3                      | 3 | 4 | 4 | 5 | 6 |
| 3         | 1         | 3                      | 3 | 4 | 4 | 5 | 6 |
| 3         | 2         | 3                      | 3 | 4 | 4 | 5 | 6 |
| 4         | 1         | 4                      | 4 | 4 | 4 | 5 | 6 |
| 4         | 2         | 4                      | 4 | 4 | 4 | 5 | 6 |
| 5         | 1         | 4                      | 4 | 4 | 4 | 5 | 6 |
| 5         | 2         | 4                      | 4 | 4 | 4 | 5 | 6 |
| 6         | 1         | 5                      | 5 | 5 | 5 | 6 | 7 |
| 6         | 2         | 5                      | 5 | 5 | 5 | 6 | 7 |
| 6         | 3         | 6                      | 6 | 6 | 6 | 7 | 8 |
| 6         | 4         | 6                      | 6 | 6 | 6 | 7 | 8 |
| 6         | 5         | 6                      | 6 | 6 | 6 | 7 | 8 |
| 6         | 6         | 6                      | 6 | 6 | 6 | 7 | 8 |
| 6         | 7         | 7                      | 7 | 7 | 7 | 8 | 9 |
| 6         | 8         | 7                      | 7 | 7 | 7 | 8 | 9 |
| 6         | 9         | 8                      | 8 | 8 | 8 | 9 | 9 |
| 6         | 3         | 9                      | 9 | 9 | 9 | 9 | 9 |

Table C

| Wrist / Arm Score | Neck, Trunk, Leg Score |   |   |   |   |   |    |
|-------------------|------------------------|---|---|---|---|---|----|
|                   | 1                      | 2 | 3 | 4 | 5 | 6 | 7+ |
| 1                 | 1                      | 1 | 2 | 3 | 3 | 4 | 5  |
| 2                 | 2                      | 2 | 3 | 3 | 4 | 4 | 5  |
| 3                 | 3                      | 3 | 3 | 4 | 4 | 5 | 6  |
| 4                 | 4                      | 3 | 3 | 4 | 4 | 5 | 6  |
| 5                 | 4                      | 4 | 4 | 4 | 5 | 6 | 7  |
| 6                 | 4                      | 4 | 5 | 6 | 6 | 7 | 7  |
| 7                 | 5                      | 5 | 6 | 6 | 7 | 7 | 7  |
| 8+                | 5                      | 5 | 6 | 7 | 7 | 7 | 7  |

Scoring (Final score from Table C)  
1-2 = acceptable posture  
3-4 = further investigation, change may be needed  
5-6 = further investigation, change soon  
7 = investigate and implement change

RULA Score

### B. Neck, Trunk and Leg Analysis

#### Step 9: Locate Neck Position:



Step 9a: Adjust...  
If neck is twisted: +1  
If neck is side bending: +1

Neck Score

#### Step 10: Locate Trunk Position:



Step 10a: Adjust...  
If trunk is twisted: +1  
If trunk is side bending: +1

Trunk Score

#### Step 11: Legs:

If legs and feet are supported: +1  
If not: +2

Leg Score

#### Step 12: Look-up Posture Score in Table B:

Using values from steps 9-11 above, locate score in Table B

#### Step 13: Add Muscle Use Score

If posture mainly static (i.e. held >1 minute), or if action repeated occurs 4X per minute: +1

Posture B Score

#### Step 14: Add Force/Load Score

If load < 4.4 lbs. (intermittent): +0  
If load 4.4 to 22 lbs. (intermittent): +1  
If load 4.4 to 22 lbs. (static or repeated): +2  
If more than 22 lbs. or repeated or shocks: +3

Muscle Use Score

#### Step 15: Find Column in Table C

Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in Table C.

Force / Load Score

Neck, Trunk, Leg Score

| Section A - Chair   |   | AREA SCORE  |
|---|---|---|
| Chair Height  |   | Non-Adjustable (+1)   |
| Knees at 90° (1)  | Too low - Knee Angle <90° (2)   | Too High - Knee Angle >90° (2)  |
| No foot contact on ground (3)                                     | Insufficient Space Under Desk - Ability to Cross Leg (+1)               |   |
| Pan Depth   |   | AREA SCORE  |
|   |   | Non-Adjustable (+1)   |
| Approximately 3 inches of space between knee and edge of seat (1) | Too Long - Less Than 3" of space (2)                                    | Too Short - More than 3" of space (2)   |
| Armrests  |   | AREA SCORE  |
|   |   | Non-Adjustable (+1)   |
| Elbows supported in line with shoulder, shoulders relaxed (1)     | Too High (Shoulders Shrugged) / Low (Arms Unsupported) (2)              | Hard / Damaged surface (+1)   |
| Back Support  |   | AREA SCORE  |
|   |   | Back Rest Non-Adjustable (+1)   |
| Adequate Lumbar Support - Chair reclined between 95°-110° (1)     | No Lumbar Support OR Lumbar Support not Positioned in Small of Back (2) | Angled Too Far Back (Greater than 110°) OR Angled Too far forward (Less than 95°) (2) |
| No Back Support (at Stool, OR Worker Leaning forward) (2)         |   | Work Surface too High (Shoulders Shrugged) (+1)                                       |
| Chair   | Monitor and Telephone   | Mouse and Keyboard  |
| DURATION  |   | CHAIR SCORE   |
|   |   | ROSA FINAL SCORE  |

# Procedure



<https://twitter.com/motognosis/status/968494945358278656/photo/1>

<https://www.cubemos.com/skeleton-tracking-sdk>

# Implementation



Sample Screenshot of Live Score Output

Labeled Joints

Calculated Angles

Made Reasonable Assumptions

User Input in Extreme Cases

Displayed Calculated Scores in Real Time

**Results**



## Assumptions/Modifications

### RULA

- Step 2A: We assumed that one arm would be working across the midline or out to the side of the body (+1 to Lower Arm Score)
- Step 3: Wrist scores: +1 would be if wrist was supported, +3 if not supported (we assumed the wrist would never be bent from the midline)
- Step 6: Posture was assumed to be mainly static (+1 to Muscle Use Score)
- Step 7: Assumed the Force Load score was <4.4 lbs (+0 to Force/Load Score)
- Step 9: Neck flexion and extension treated the same (+4 for neck extension to +3)
- Step 10: Assumed the trunk wouldn't be twisting (+0 to Trunk Score)
- Step 13: Assumed posture would be mainly static (+1 to Muscle Use Score)
- Step 14: Assumed force load score was <4.4 lbs (+0 to Force/Load Score)

### ROSA

- Chair height and arm rests are adjustable
- Arm rests are not on a hard/damaged surface and are not too widely spread.

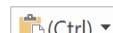
### Questions to Ask (User Input)

#### RULA

- (Wrist Score) Is the wrist supported? Yes: +1, No: +3
- (Upper Arm Score) Is arm supported? Yes: 1, No: +0
- (Wrist Twist) Will the wrist be bent near the end of its range? Yes: +2, No: +1
- (Leg Score) Are the legs and feet supported? Yes: +1, No: +2

#### ROSA

- Chair: Are the legs and feet supported? (answer can be taken from RULA) Yes: immediate 3
- Chair: Is there insufficient space under the desk/can you not cross your legs? Yes: +1
- Pan Depth: Is there around 3 inches of space between knees and the edge of the seat? Yes:1 No:2
- Back Support: Is there adequate Lumbar Support? Yes: check if chair between 95:110 degrees (1), No: 2
- Back Support: Is the backrest adjustable? No: +1
- Pan Depth: Is seat pan depth adjustable? No: +1



Not as automated as initially planned- lots of assumptions and user input questions

Difficulty with multiple people in frame

Tested individual angles to see if readings were reasonable

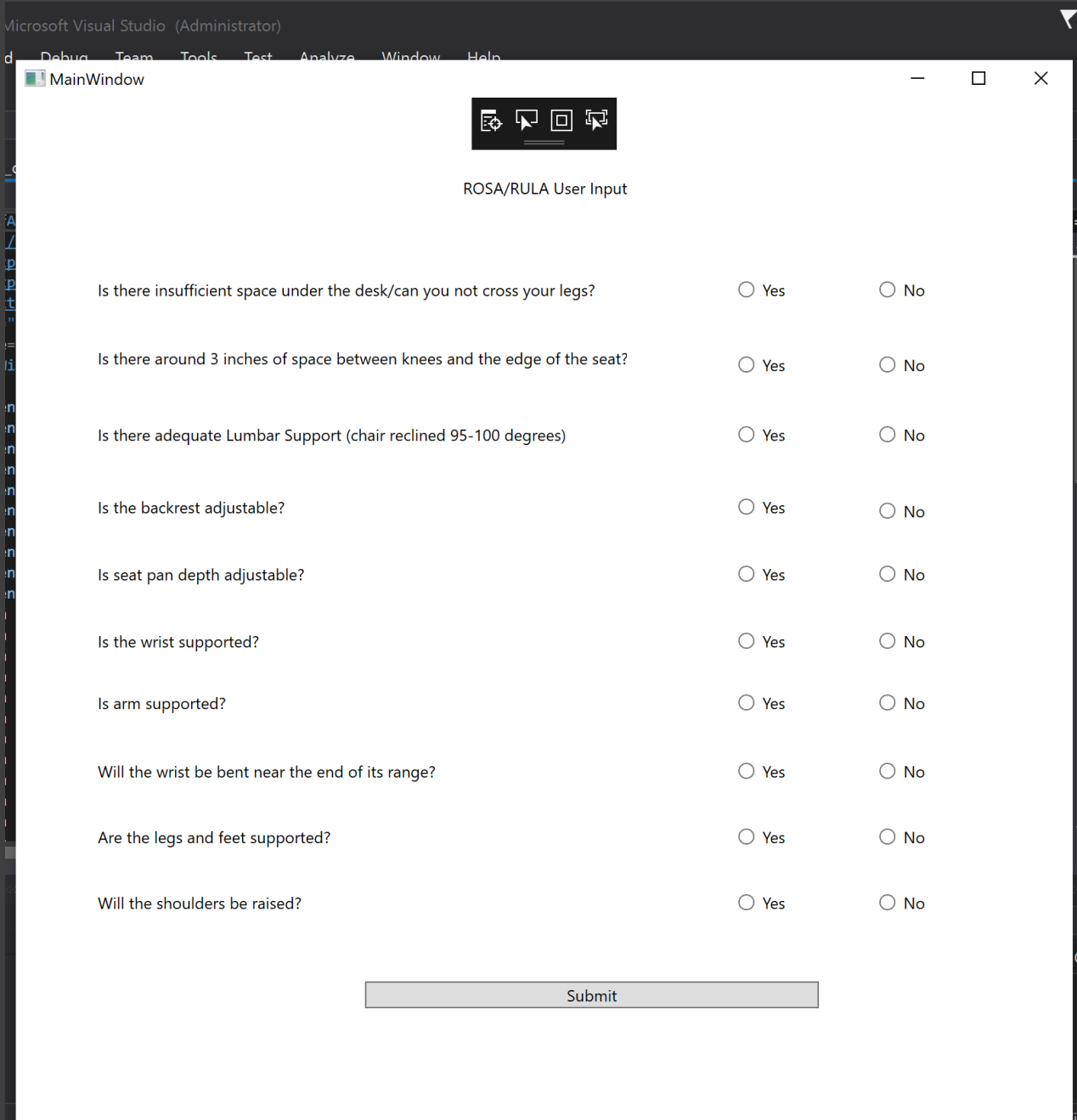
Assumed good postures to test whether scores went down

Bug tested to avoid crashing

Documented Process

A green rectangular sign with rounded corners and a white border, mounted on two metal poles. The sign features the word "Future" in a large, white, sans-serif font. The background is a bright blue sky with scattered white clouds.

**Future**



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Implement GUI for user input (in process)

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Reduce assumptions and user input

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Expand beyond real time videos

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Graphical/statistical analysis of how long time is spent in each score

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Areas to be researched: CNNs, Machine Learning

# Lessons Learned

Importance of ergonomics and existing algorithms to calculate scores

GUI creation

CNNs, AI

RGBD cameras and their effectiveness in computer vision

Plan better for long projects

Teamviewer for working virtually

# Citations

- Józwiak Z, Makowiec Dąbrowska T, Gadzicka E, Siedlecka J, Szyjkowska A, Kosobudzki M, Viebig P, Bortkiewicz A. Zastosowanie metody ROSA do oceny obciążenia układu mięśniowo-szkieletowego na komputerowych stanowiskach pracy [Using of the ROSA method to assess the musculoskeletal load on computer workstations]. Med Pr. 2019 Dec 3;70(6):675-699. Polish. doi: 10.13075
- Davudian-Talab, Amirhossein & Azari, Gholamreza & Badfar, Gholamreza & Shafeei, Asrin & Derakhshan, Zainab. (2017). Evaluation and Correlation of the Rapid Upper Limb Assessment and Rapid Office Strain Assessment Methods for Predicting the Risk of Musculoskeletal Disorders. Internal Medicine and Medical Investigation Journal. 2. 155. 10.24200.
- Namwongsa S, Puntumetakul R, Neubert MS, Chaiklieng S, Boucaut R (2018) Ergonomic risk assessment of smartphone users using the Rapid Upper Limb Assessment (RULA) tool. PLoS ONE 13(8): e0203394.
- Rodrigues, Mirela Sant'Ana et al. 'Differences in Ergonomic and Workstation Factors Between Computer Office Workers with and Without Reported Musculoskeletal Pain'. 1 Jan. 2017.
- AIP Conference Proceedings 1883, 020034 (2017); <https://doi.org/10.1063/1.5002052> Published Online: 14 September 2017
- Dabholkar, Twinkle Yogesh et al. "Objective ergonomic risk assessment of wrist and spine with motion analysis technique during simulated laparoscopic cholecystectomy in experienced and novice surgeons." Journal of minimal access surgery vol. 13,2 (2017): 124-130. doi:10.4103/0972-9941.195574
- Gómez-Galán, M.; Callejón-Ferre, Á.-J.; Pérez-Alonso, J.; Díaz-Pérez, M.; Carrillo-Castrillo, J.-A. Musculoskeletal Risks: RULA Bibliometric Review. Int. J. Environ. Res. Public Health 2020, 17, 4354. <https://doi.org/10.3390/ijerph17124354>

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