# A Classification and Systematic Literature Review of Fundamental Parallel Closing Mechanisms

Thomas de Jager (4489020)

11/02/2021

Supervisors:
Dr. Tim Horeman
MSc. Tomas Lenssen

ME51010 Literature and Introductory Colloquium

TU Delft

# A Classification and Systematic Literature Review of Fundamental Parallel Closing Mechanisms

# A Classification and Systematic Literature Review of Fundamental Parallel Closing Mechanisms

Categorisation

# A Classification and Systematic Literature Review of Fundamental Parallel Closing Mechanisms

Search methodology & meta-analysis

# A Classification and Systematic Literature Review of Fundamental Parallel Closing Mechanisms

Working principles

# A Classification and Systematic Literature Review of Fundamental Parallel Closing Mechanisms

Gripper jaws moving in parallel

# Contents

- Problem statement
- Search methodology
- GSQUIP
- Search results
- Classification
- Discussion
- Conclusion
- Graduation project

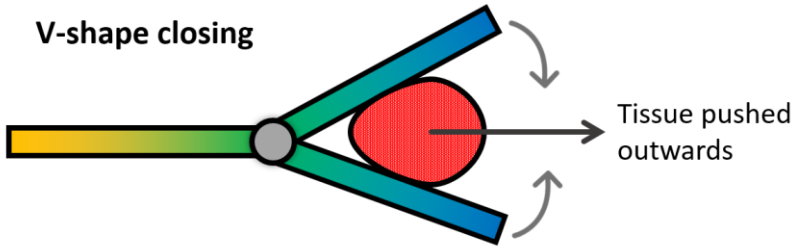
# Problem statement

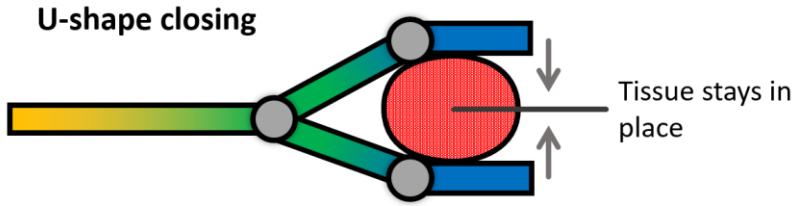
- V-shape clip appliers

[1]

# Problem statement

- V-shape clip appliers
  - Force outward
  - Peak stress



# Problem statement

- V-shape clip appliers
  - Force outward
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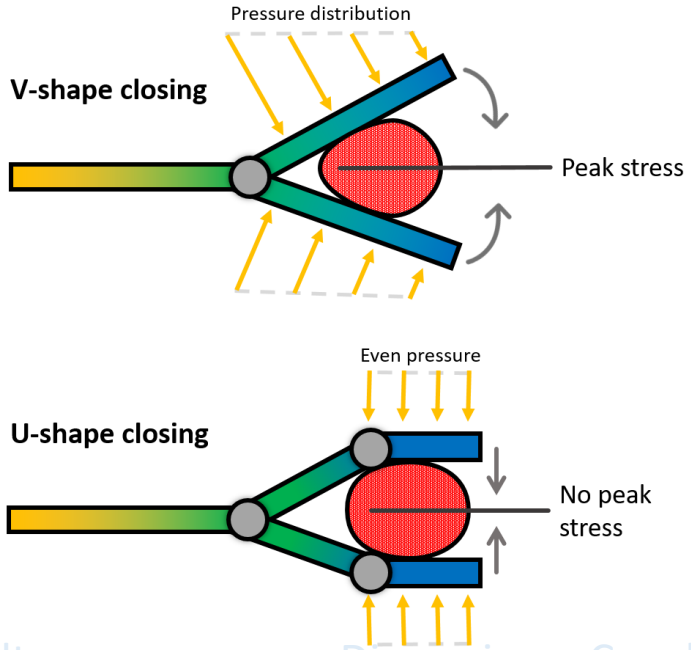
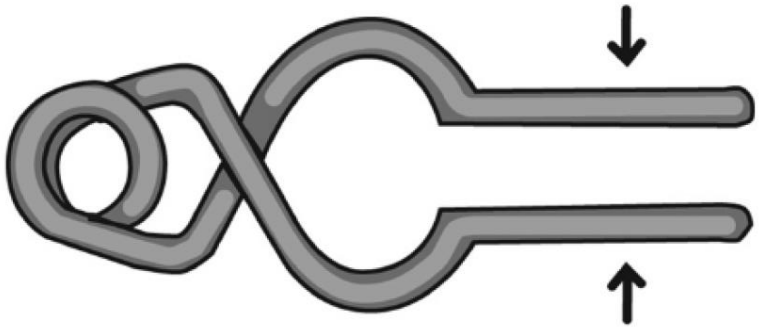


# Problem statement

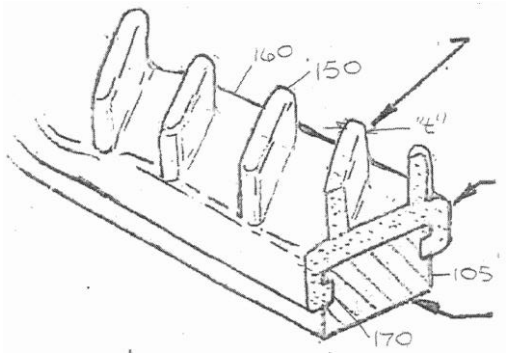
- V-shape clip appliers
  - Force outward
  - Peak stress
  - Avoiding fundamental problem
    - Modifying hinge [67]

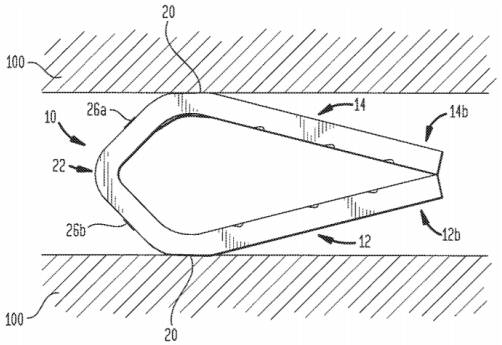


[156]

# Problem statement

- V-shape clip appliers
  - Force outward
  - Peak stress
  - Avoiding fundamental problem
    - Modifying hinge [67]
    - Pre bending tip [132]
    - Increase friction [132]



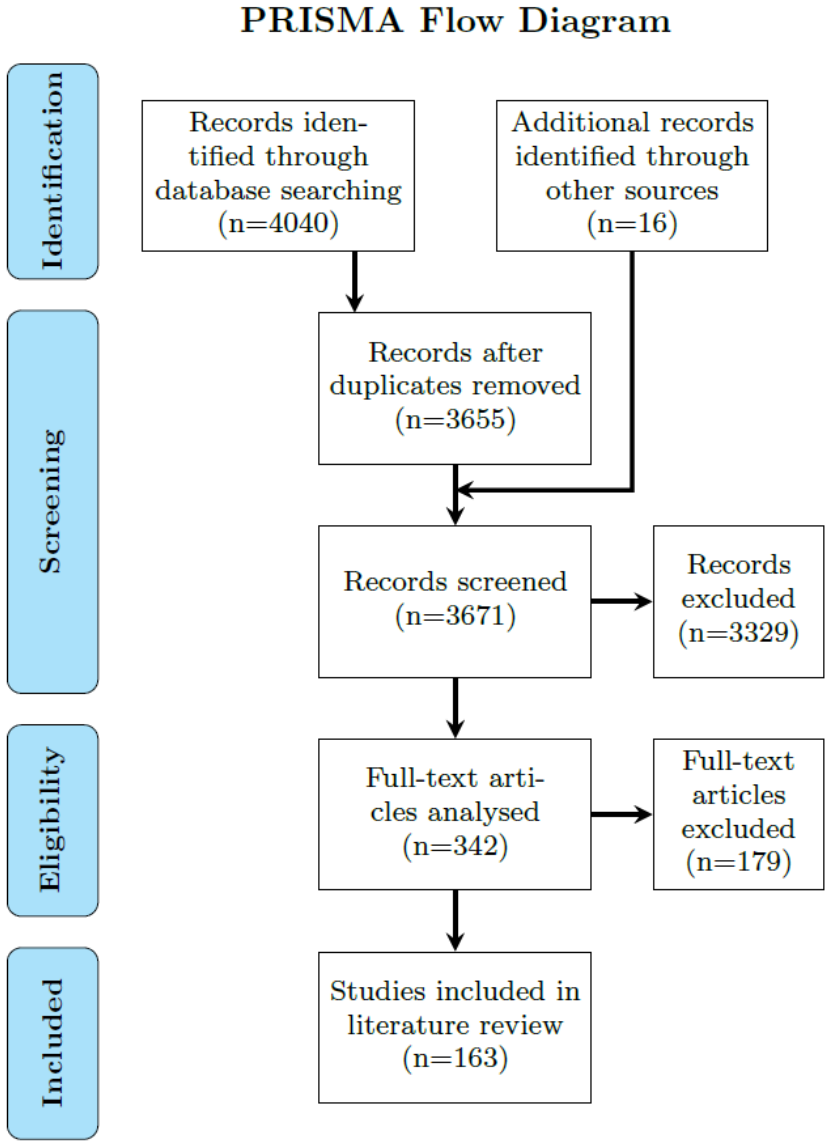

[132]

# Literature research question

*“What are the state-of-the-art parallel closing mechanisms and how can these be classified?”*

# Search methodology

- PRISMA
  (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
  - Identification
  - Screening
  - Eligibility
  - Included



# Search methodology

- Search engines

| Search engine name | Type of database |
|---|---|
| PubMed | Subject-specific: medical |
| ScienceDirect | Multidisciplinary |
| Web of Science | Multidisciplinary |
| Scopus | Multidisciplinary |
| IEEE Xplore | Multidisciplinary |
| Google Scholar | Multidisciplinary |

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- Search engines

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# Search methodology

- Search engines
- Workflow

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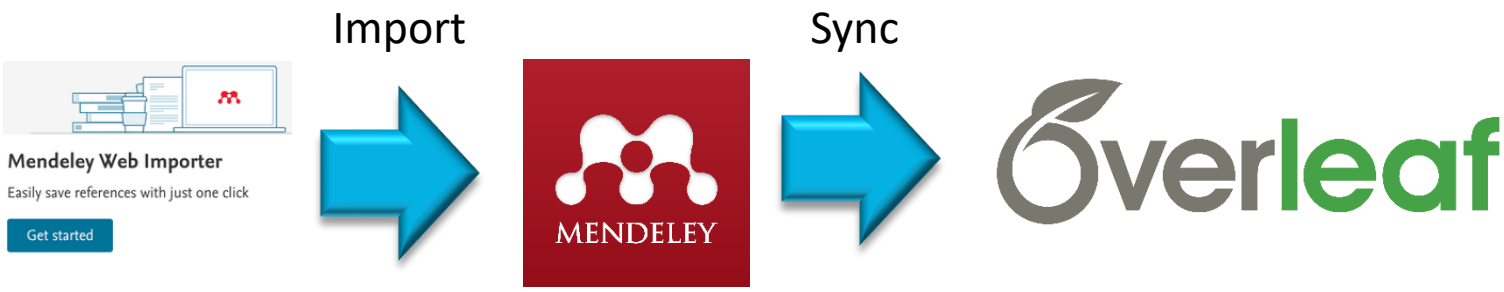
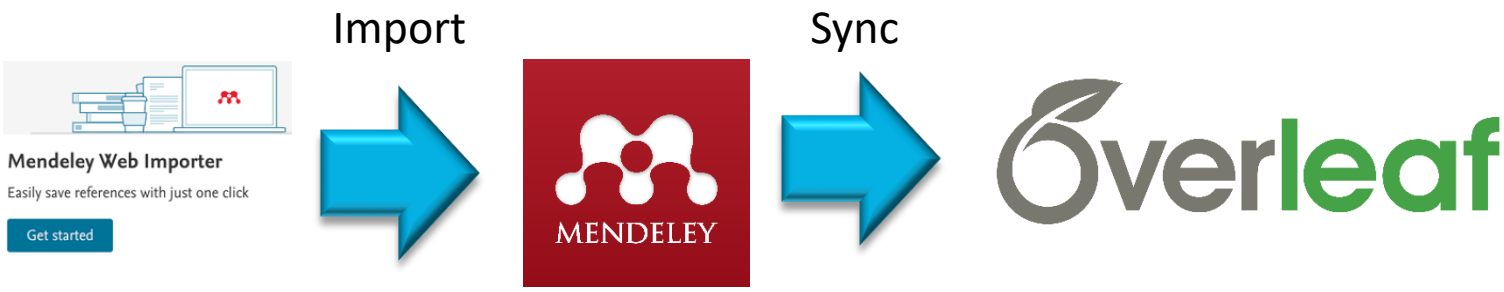


# Search methodology

- Search engines
- Workflow
- GitHub [3]

| Search engine name | Type of database |
|---|---|
| PubMed | Subject-specific: medical |
| ScienceDirect | Multidisciplinary |
| Web of Science | Multidisciplinary |
| Scopus | Multidisciplinary |
| IEEE Xplore | Multidisciplinary |
| Google Scholar | Multidisciplinary |



# Search queries

- Keywords

| WSQ | Exact phrase | And |
|---|---|---|
| 1 | Parallel closing mechanism | |
| 2 | Parallel clamping | mechanism OR gripper OR device |
| 3 | Parallel closing | mechanism OR gripper OR device |
| 4 | Parallel gripper | |
| 5 | Parallel grasping | mechanism OR device OR gripper |
| 6 | Parallel linkage | mechanism OR device OR gripper |
| 7 | Clip applier | parallel |
| 8 | Compliant gripper | parallel |
| 9 | Origami gripper | parallel |
| Total | | |

# Search queries

- Keywords
  - Inclusion
  - Exclusion

| WSQ | Exact phrase | And | Year | NOT | Language |
|---|---|---|---|---|---|
| 1 | Parallel closing mechanism | | | "non-parallel" | GB, NL, DE, FR |
| 2 | Parallel clamping | mechanism OR gripper OR device | 2010-20 | "non-parallel" | GB, NL, DE, FR |
| 3 | Parallel closing | mechanism OR gripper OR device | 2000-20 | "non-parallel" | GB, NL, DE, FR |
| 4 | Parallel gripper | | 2010-20 | "non-parallel", "statically balanced", "motion platform", "constant-force", "parallel manipulator" | GB, NL, DE, FR |
| 5 | Parallel grasping | mechanism OR device OR gripper | | "non-parallel" | GB, NL, DE, FR |
| 6 | Parallel linkage | mechanism OR device OR gripper | 2010-20 | "non-parallel", "statically balanced", "motion platform", "constant-force", "parallel manipulator" | GB, NL, DE, FR |
| 7 | Clip applier | parallel | 2010-20 | "non-parallel" | GB, NL, DE, FR |
| 8 | Compliant gripper | parallel | 2010-20 | "non-parallel", "statically balanced", "motion platform", "constant-force", "parallel manipulator" | GB, NL, DE, FR |
| 9 | Origami gripper | parallel | | "non-parallel" | GB, NL, DE, FR |
| Total | | | | | |

# Search queries

- Keywords
  - Inclusion
  - Exclusion
- Records
- GSQUIP
  (Google search query uniqueness identifier program)

| WSQ | Exact phrase | And | Year | NOT | Language | Results | % Unique | % Double |
|---|---|---|---|---|---|---|---|---|
| 1 | Parallel closing mechanism | | | "non-parallel" | GB, NL, DE, FR | 4 | 0 | 50 |
| 2 | Parallel clamping | mechanism OR gripper OR device | 2010-20 | "non-parallel" | GB, NL, DE, FR | 238 | 97 | 15 |
| 3 | Parallel closing | mechanism OR gripper OR device | 2000-20 | "non-parallel" | GB, NL, DE, FR | 191 | 94 | 18 |
| 4 | Parallel gripper | | 2010-20 | "non-parallel", "statically balanced", "motion platform", "constant-force", "parallel manipulator" | GB, NL, DE, FR | 1140[1] | 94 | 1 |
| 5 | Parallel grasping | mechanism OR device OR gripper | | "non-parallel" | GB, NL, DE, FR | 186 | 79 | 4 |
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| 7 | Clip applier | parallel | 2010-20 | "non-parallel" | GB, NL, DE, FR | 413 | 100 | 8 |
| 8 | Compliant gripper | parallel | 2010-20 | "non-parallel", "statically balanced", "motion platform", "constant-force", "parallel manipulator" | GB, NL, DE, FR | 321 | 86 | 0 |
| 9 | Origami gripper | parallel | | "non-parallel" | GB, NL, DE, FR | 46 | 96 | 4 |
| Total | | | | | | 3350 | ø 83 | ø 12 |

# Search queries

- Keywords
  - Inclusion
  - Exclusion
- Records
- GSQUIP
  (Google search query uniqueness identifier program)
- Selected

| WSQ | Exact phrase | And | Year | NOT | Language | Results | % Unique | % Double | Selected |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Parallel closing mechanism | | | "non-parallel" | GB, NL, DE, FR | 4 | 0 | 50 | 2 |
| 2 | Parallel clamping | mechanism OR gripper OR device | 2010-20 | "non-parallel" | GB, NL, DE, FR | 238 | 97 | 15 | 8 |
| 3 | Parallel closing | mechanism OR gripper OR device | 2000-20 | "non-parallel" | GB, NL, DE, FR | 191 | 94 | 18 | 16 |
| 4 | Parallel gripper | | 2010-20 | "non-parallel", "statically balanced", "motion platform", "constant-force", "parallel manipulator" | GB, NL, DE, FR | 1140[1] | 94 | 1 | 17 |
| 5 | Parallel grasping | mechanism OR device OR gripper | | "non-parallel" | GB, NL, DE, FR | 186 | 79 | 4 | 31 |
| 6 | Parallel linkage | mechanism OR device OR gripper | 2010-20 | "non-parallel", "statically balanced", "motion platform", "constant-force", "parallel manipulator" | GB, NL, DE, FR | 811[1] | 99 | 3 | 1 |
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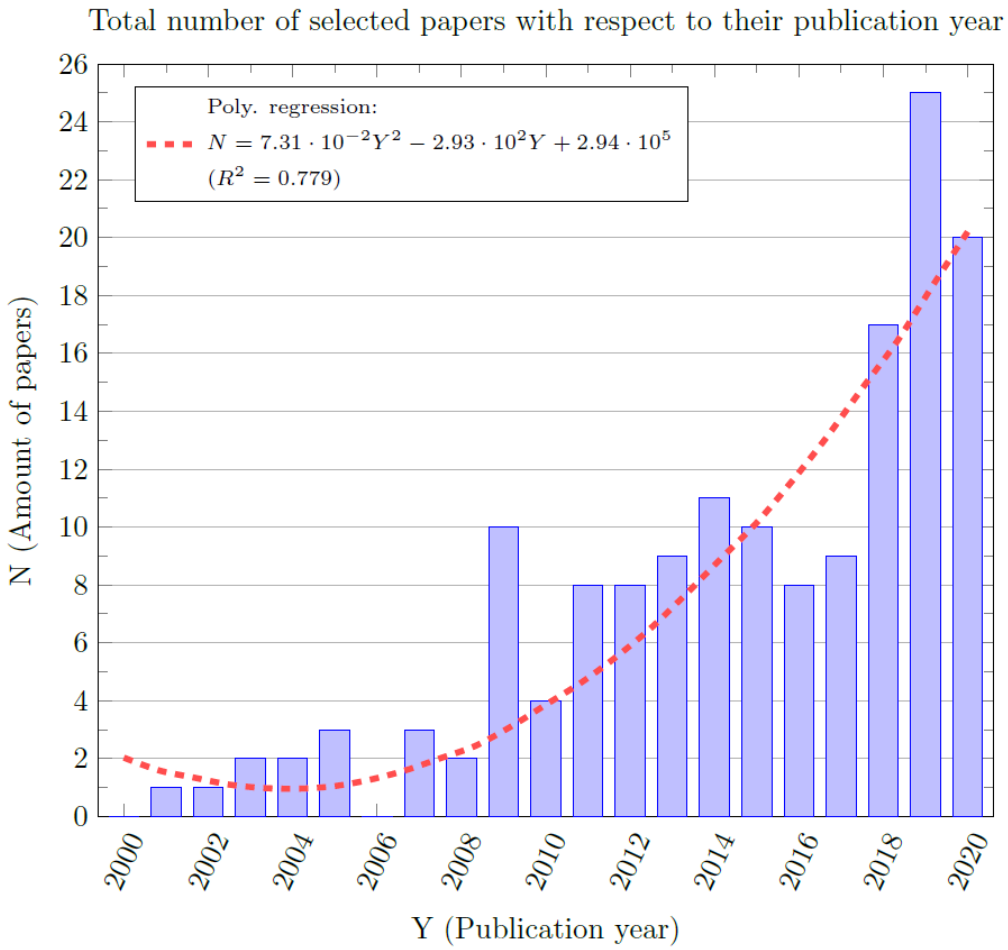
| 9 | Origami gripper | parallel | | "non-parallel" | GB, NL, DE, FR | 46 | 96 | 4 | 4 |
| Total | | | | | | 3350 | ø 83 | ø 12 | 90 |

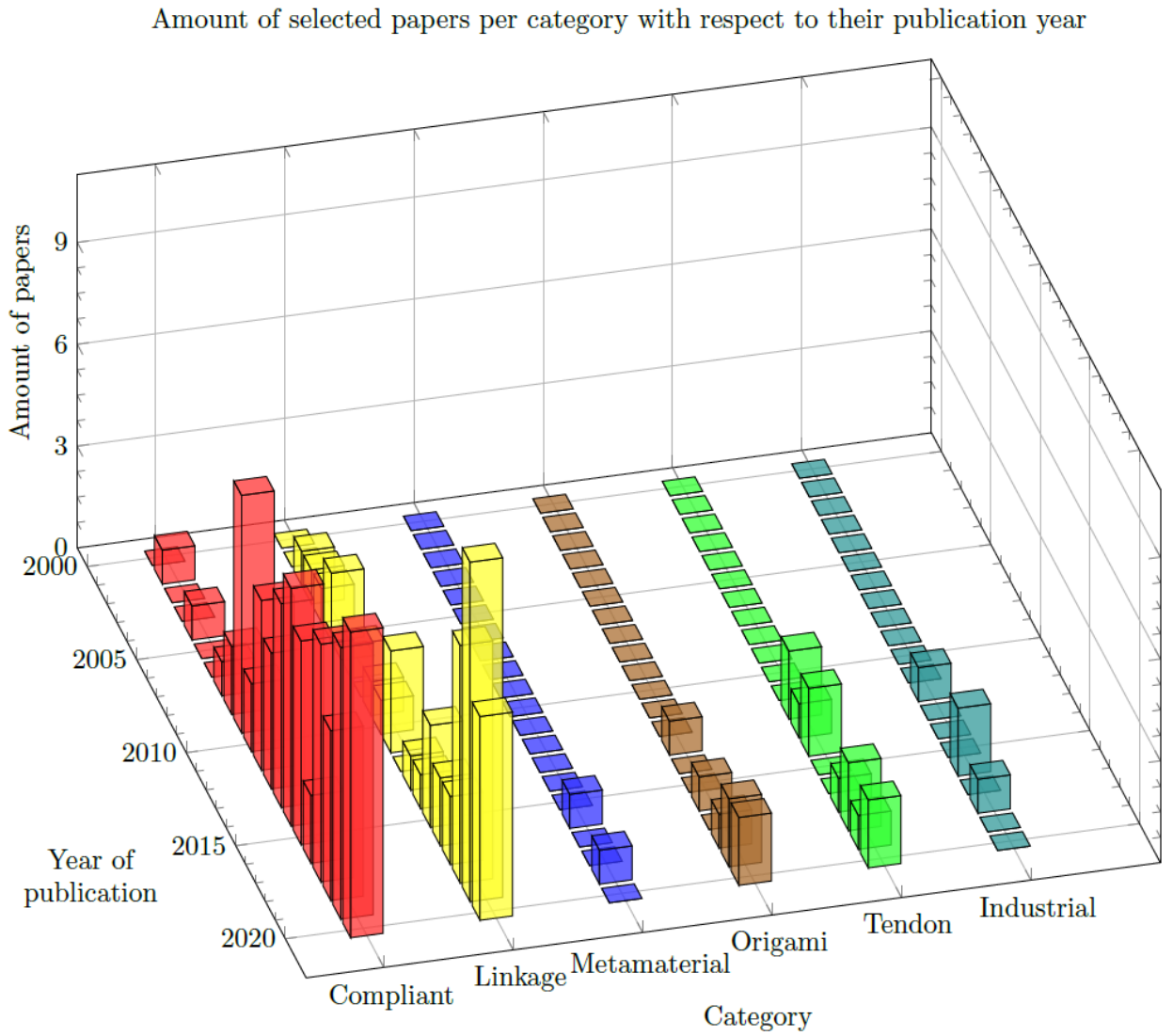
# Selected papers over time

- Increasing
  - Compliant
  - Soft robotics



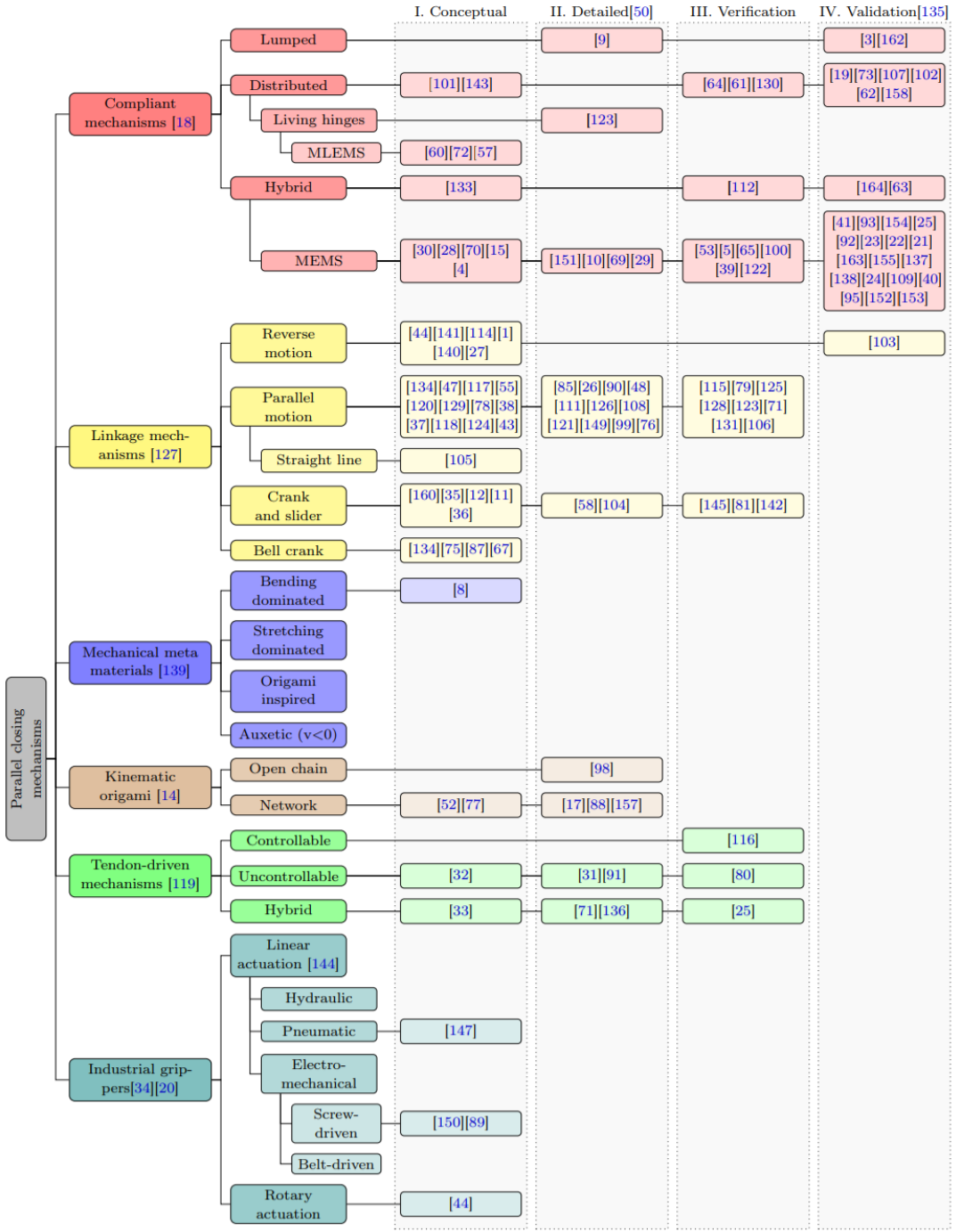
# Classification

- Compliant
- Linkage
- Meta-material
- Origami
- Tendon-driven
- Industrial



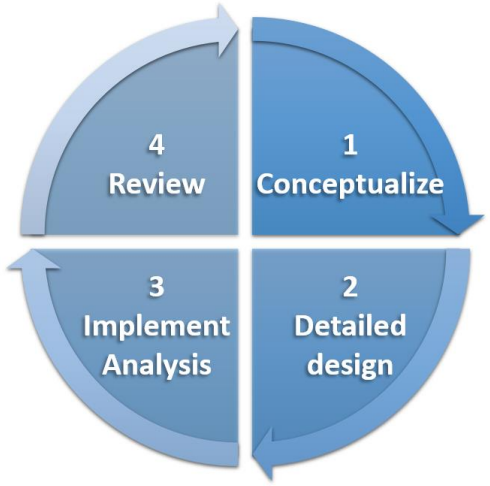
# Classification

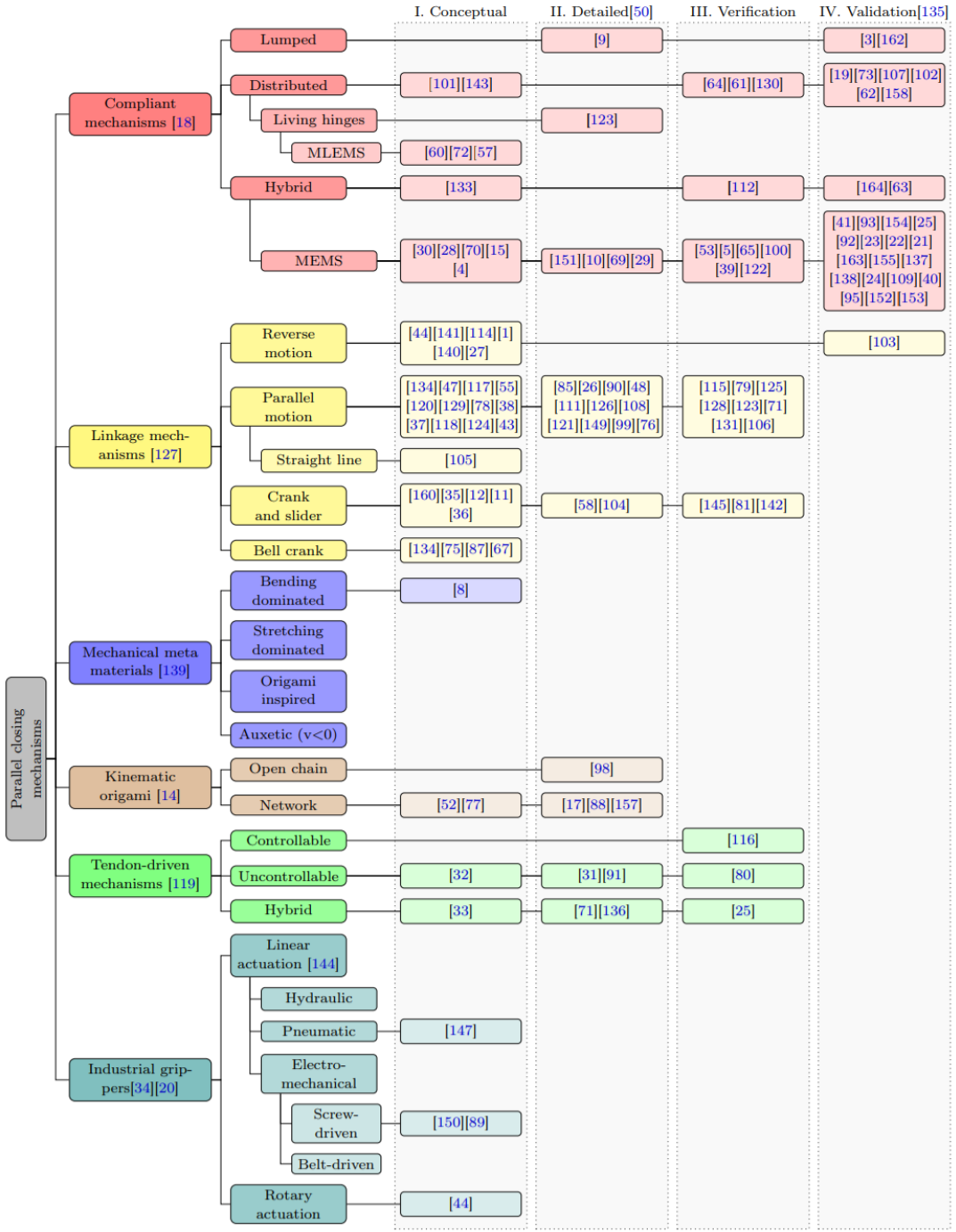
- State-of-the-art



# Classification

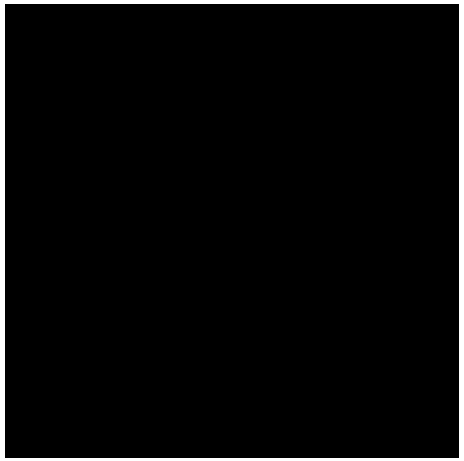
- State-of-the-art
- 2D functional scheme



# Compliant mechanisms

- Lumped
- Distributed
  - MLEM



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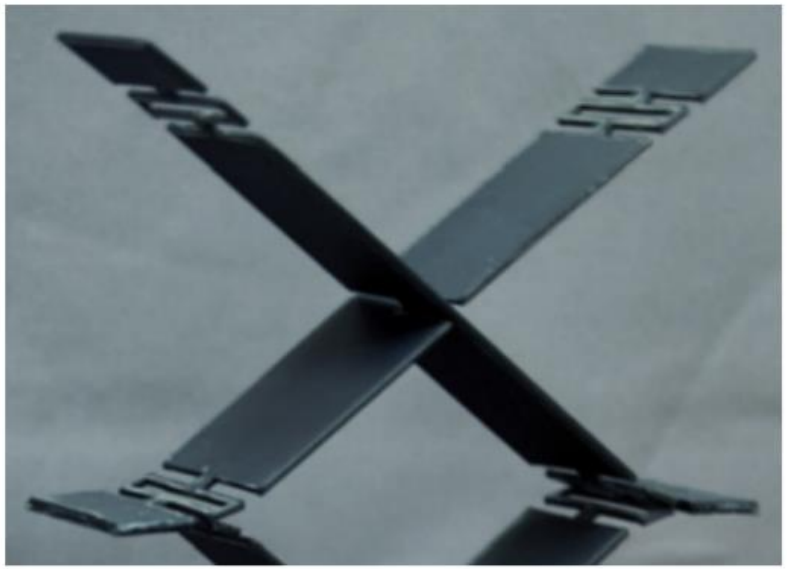
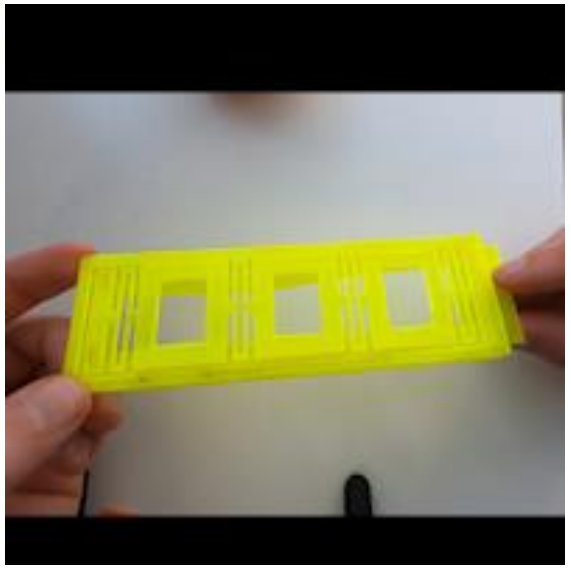
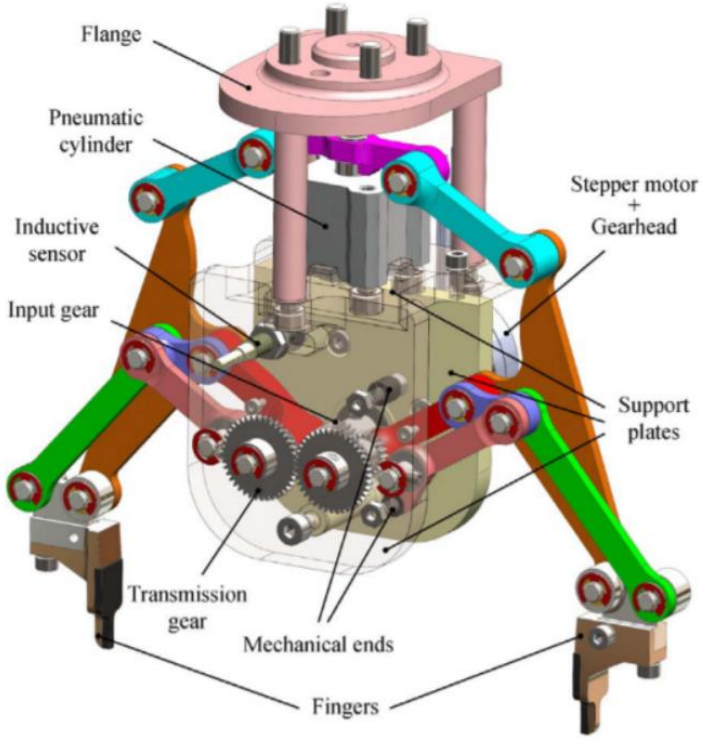




[57]

# Linkage mechanisms

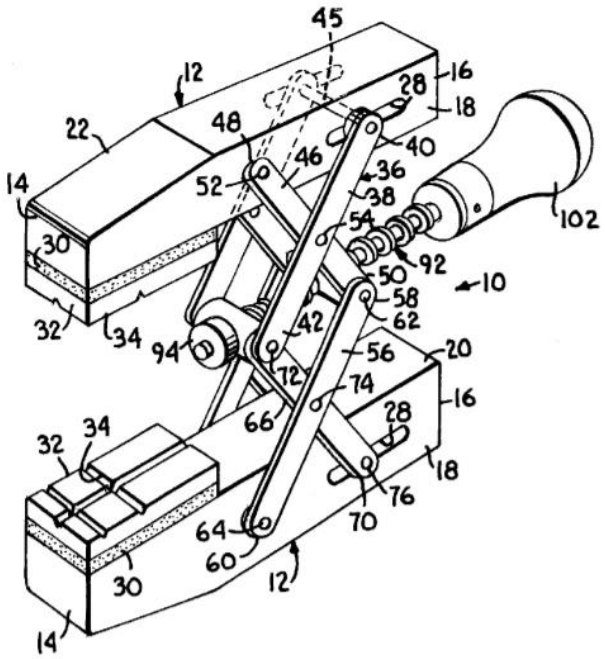
- Parallel motion
- Reverse motion
- Crank and slider
- Bell crank



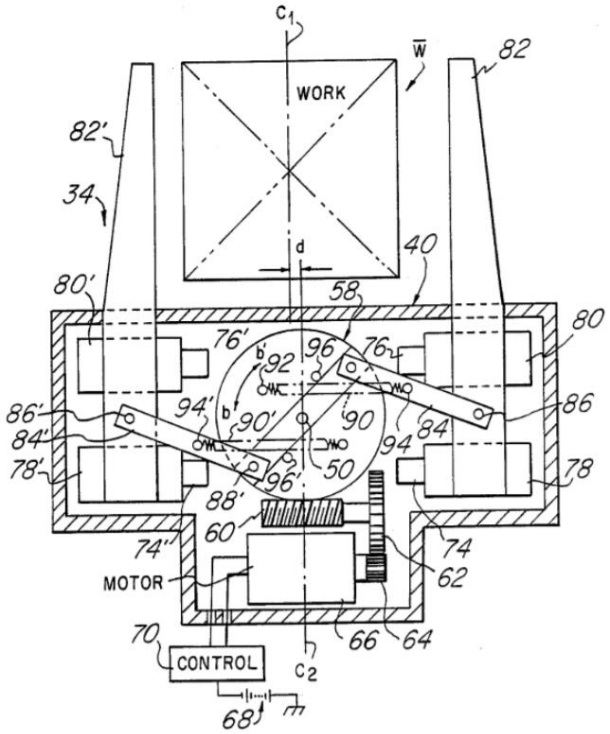

[125]

# Linkage mechanisms

- Parallel motion
- Reverse motion
- Crank and slider
- Bell crank



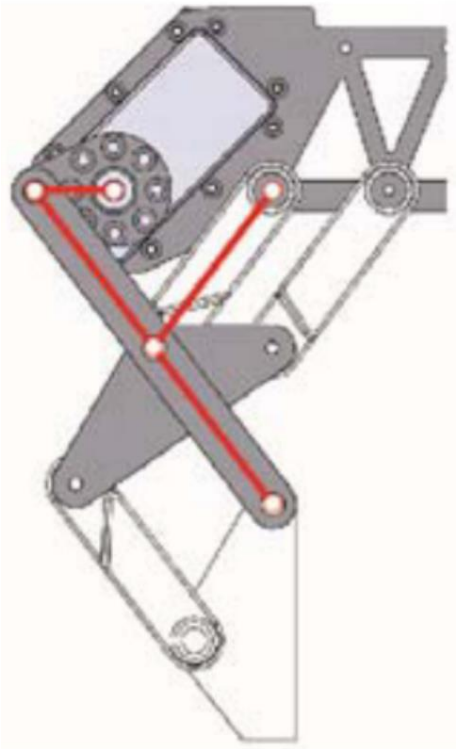

[140]



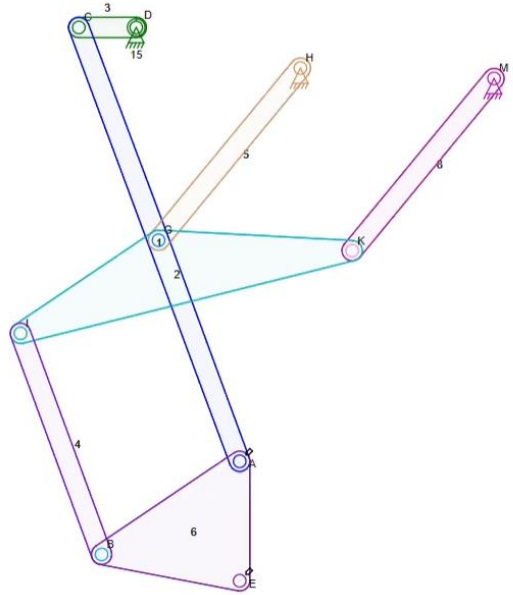

[114]

# Linkage mechanisms

- Parallel motion
- Reverse motion
- Crank and slider
- Bell crank



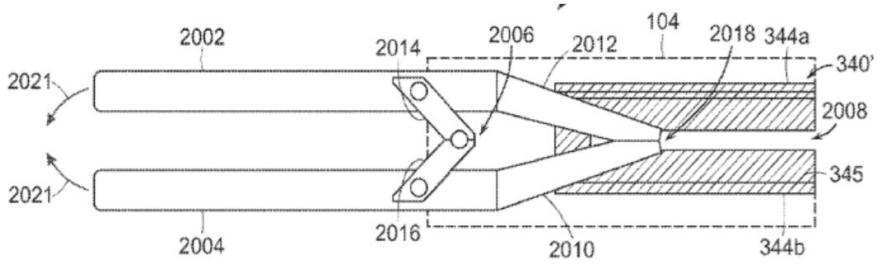
[142]



[2]

# Linkage mechanisms

- Parallel motion
- Reverse motion
- Crank and slider
- Bell crank




[75]

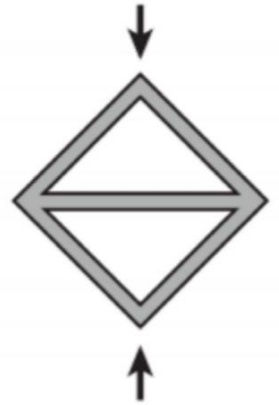
# Meta-material mechanisms

- Bending dominated
- Stretching dominated
- Origami inspired
- Auxetic ($v < 0$)

[8]

# Meta-material mechanisms

- Bending dominated
- Stretching dominated
- Origami inspired
- Auxetic (v < 0)

$$\frac{E}{Es} \sim \left(\frac{\rho}{\rho_s}\right)^2 \qquad \frac{E}{Es} \sim \left(\frac{\rho}{\rho_s}\right)$$

$$\frac{\sigma}{\sigma_y} \sim \left(\frac{\rho}{\rho_s}\right)^{1.5} \qquad \frac{\sigma}{\sigma_y} \sim \left(\frac{\rho}{\rho_s}\right)$$

[139]

# Meta-material mechanisms

- Bending dominated
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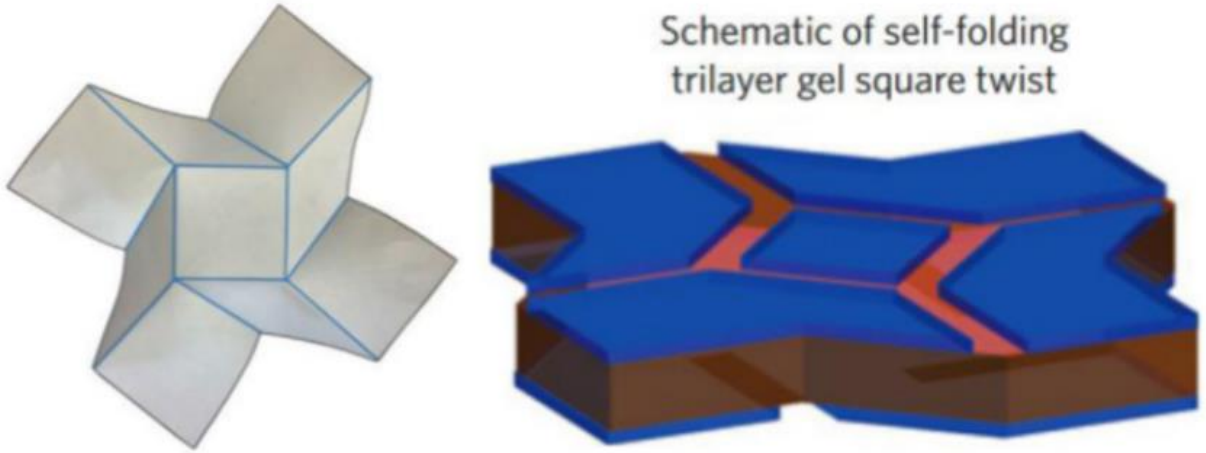
- Auxetic ($v < 0$)




[139]

# Meta-material mechanisms

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- Stretching dominated
- Origami inspired
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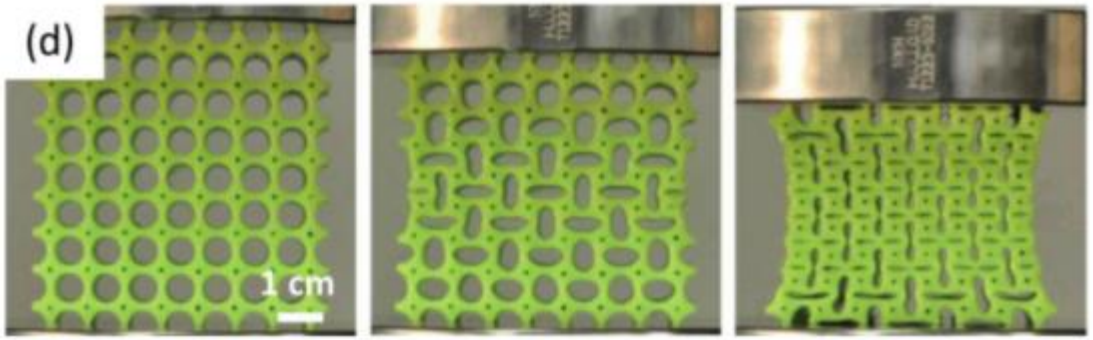
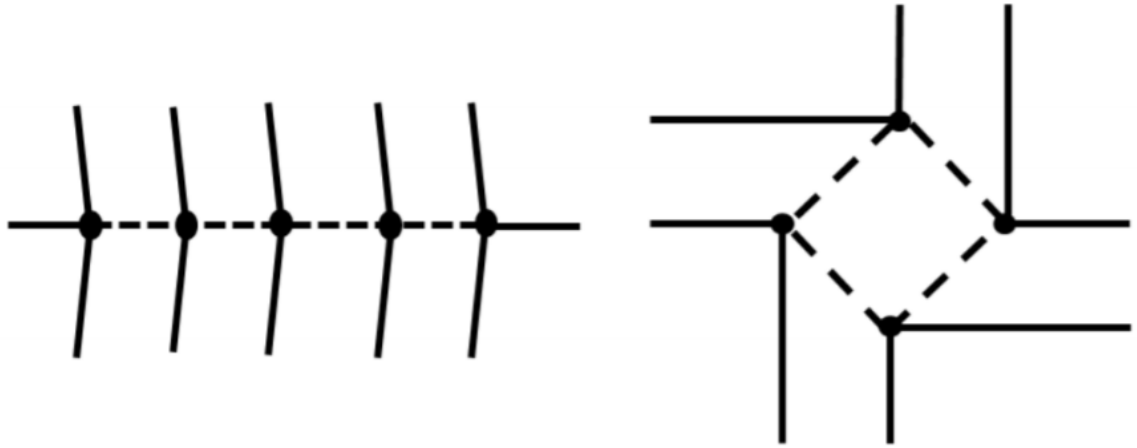



[139]

# Kinematic origami

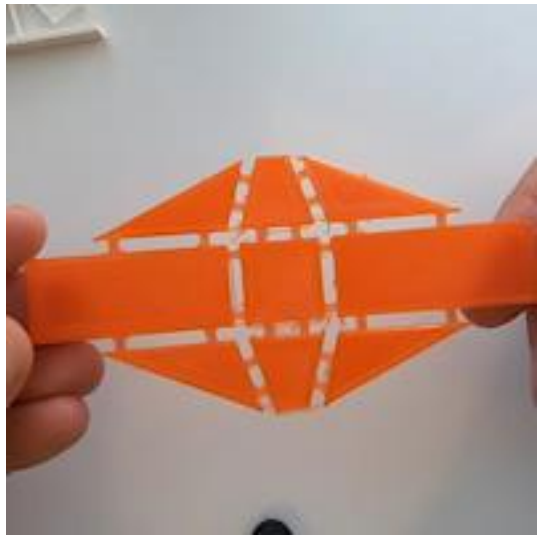
- Open chain
- Network



[14]

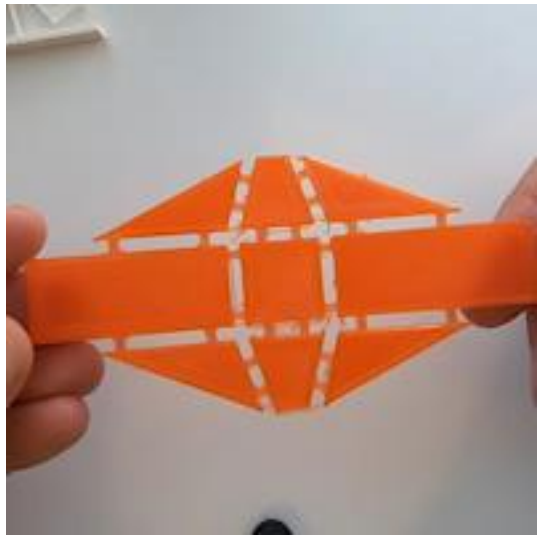
# Kinematic origami

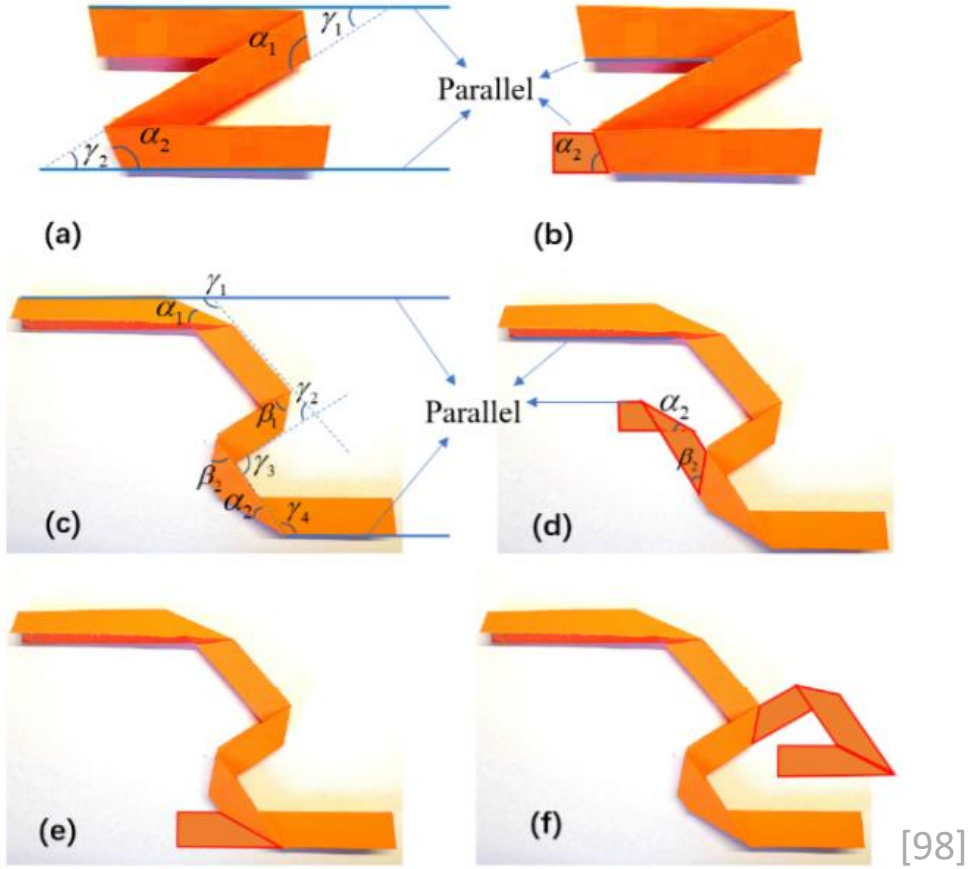
- Open chain
- Network



# Kinematic origami

- Open chain
- Network

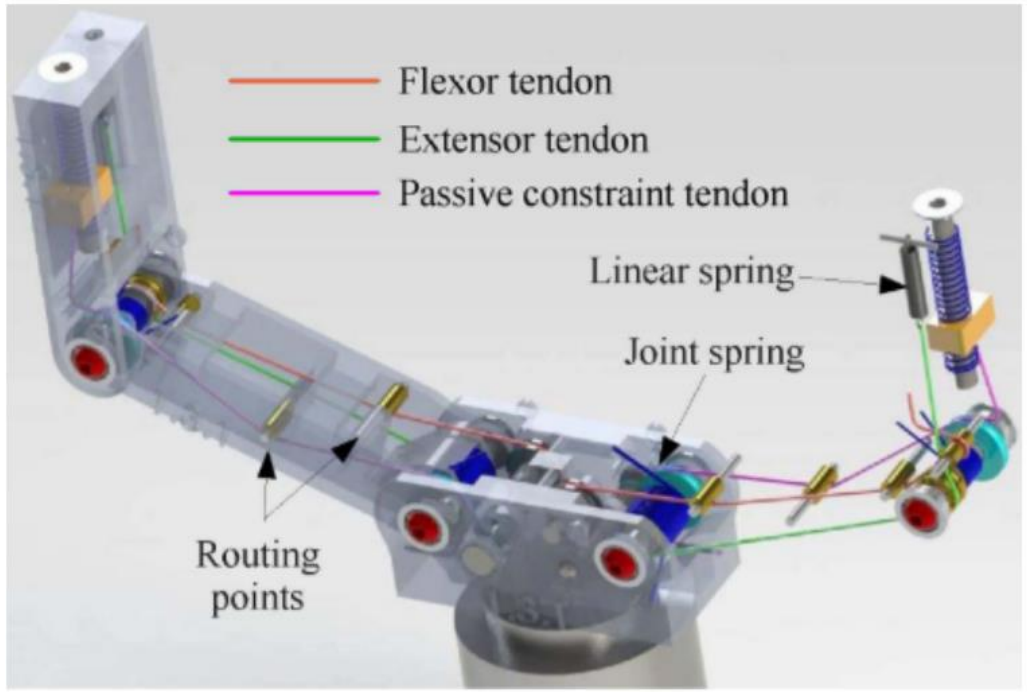





[98]

# Tendon-driven mechanisms

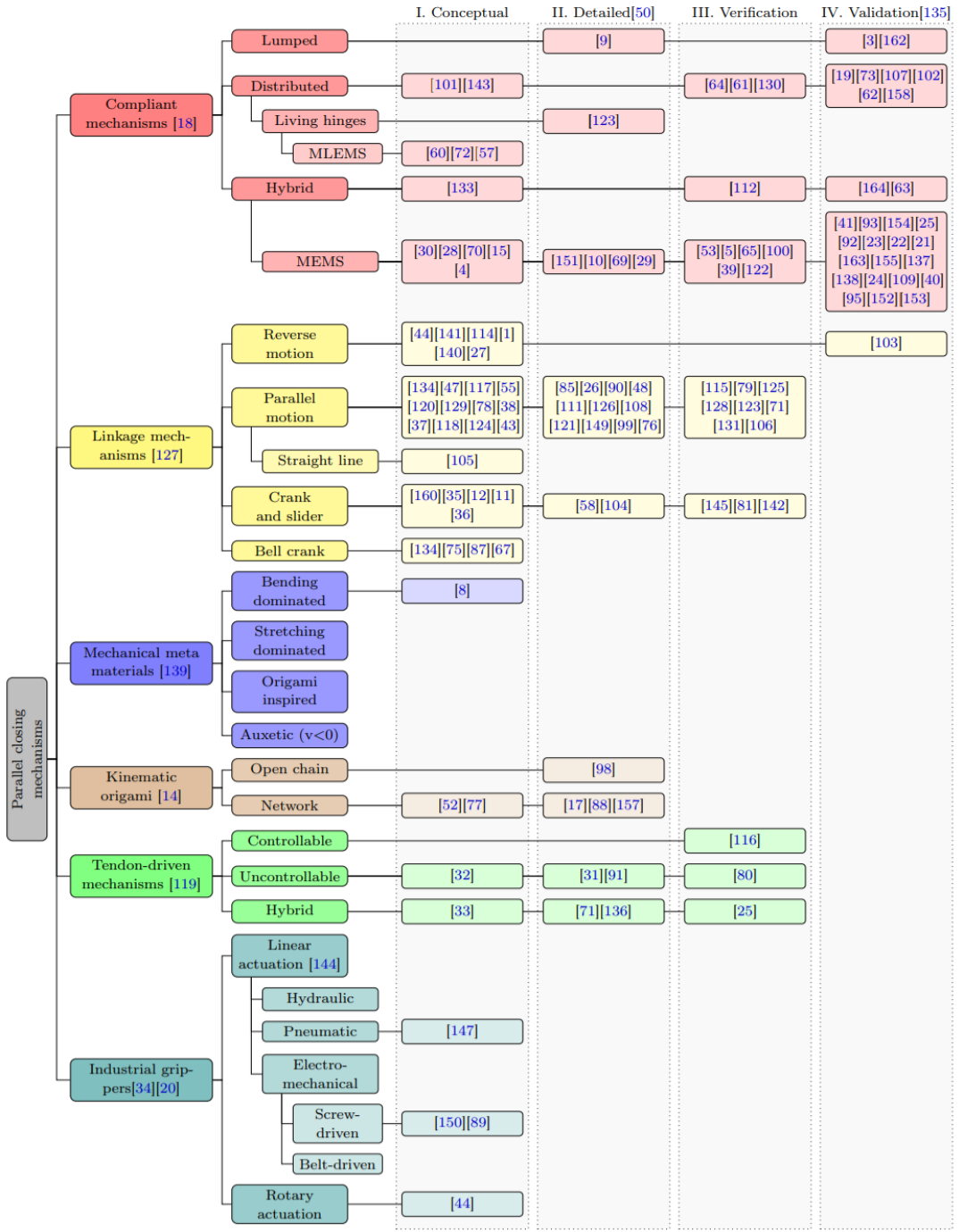
- Controllable
- Uncontrollable




[31]

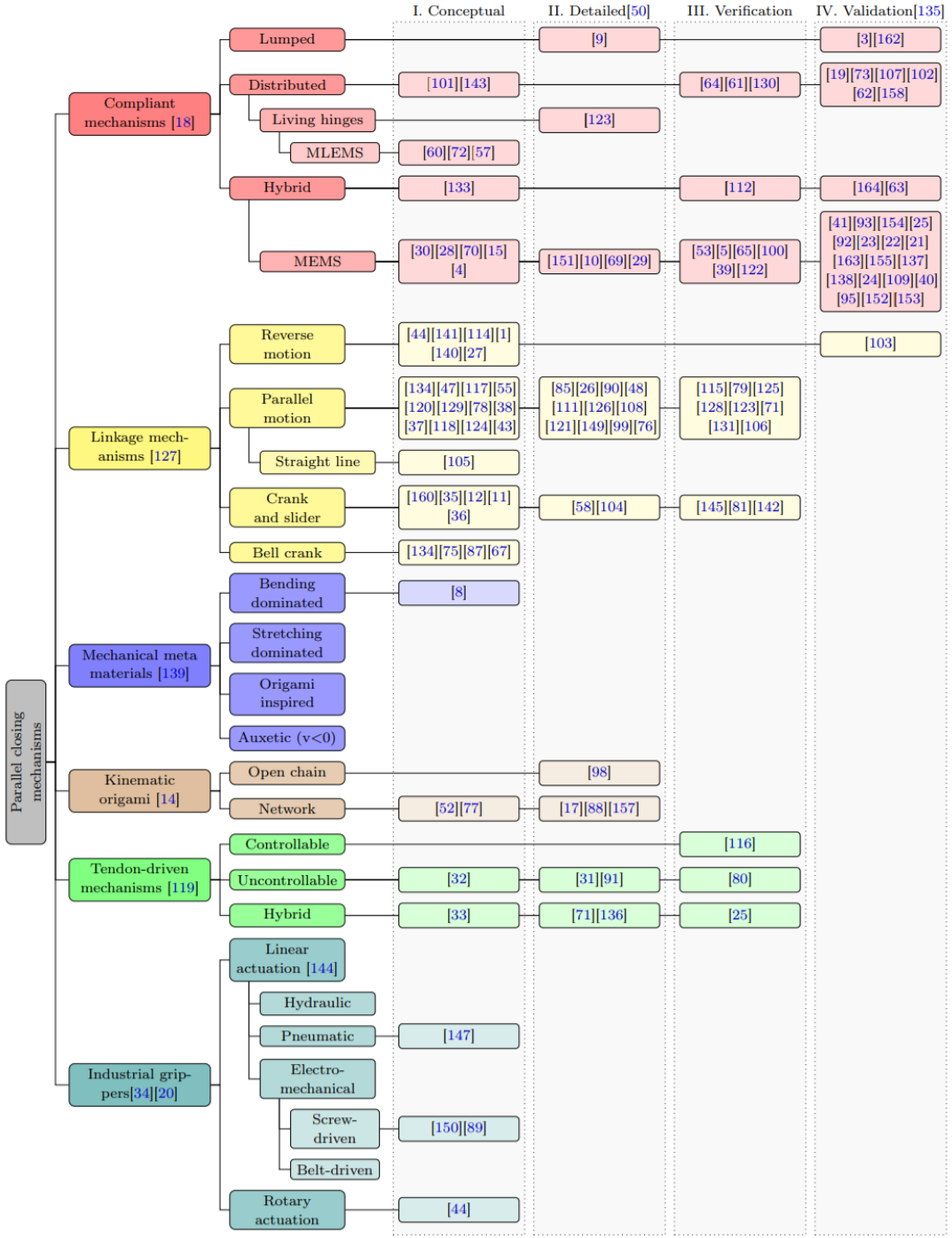
# Discussion

- Literature gap/abundance



# Conclusion

- PRISMA
  - 163 records
- 2D classification

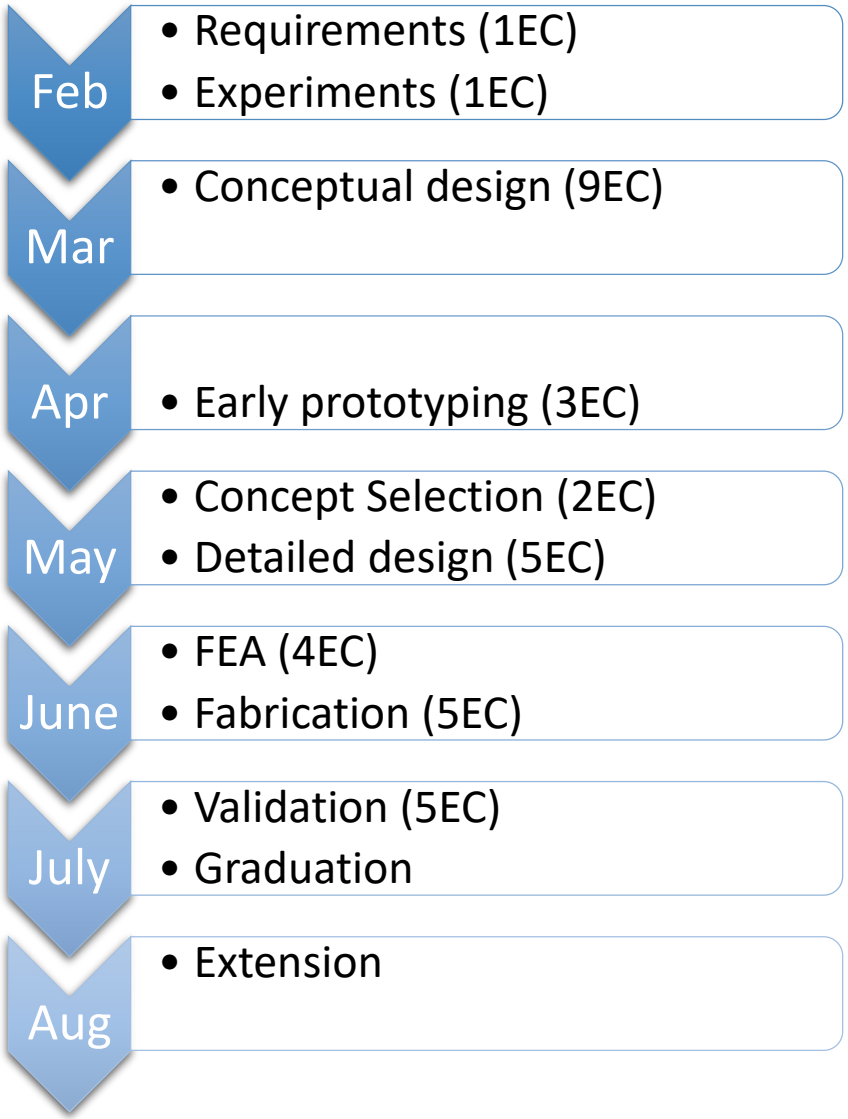


# Graduation project

- Double articulated parallel clip applier (DAPCA)
- Redesign end effector
- Parallel closing
- Preferably compliant

# Graduation timeline

- Design project (35EC)



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TU Delft

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