Tables Got Moves
A Review on Actuated Table Designs

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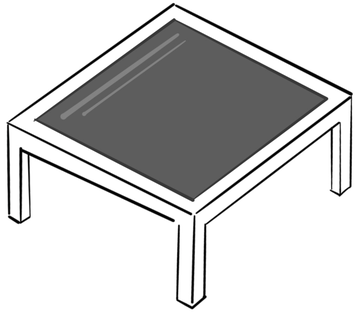
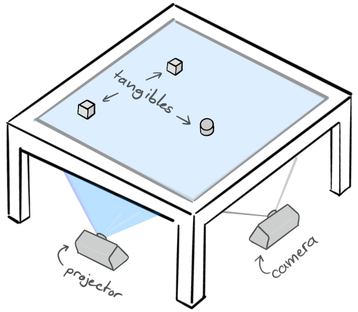
Research
Council

what is an **actuated table?**

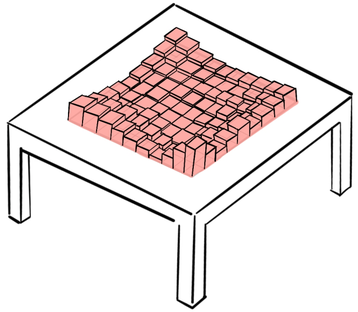
digital tabletop



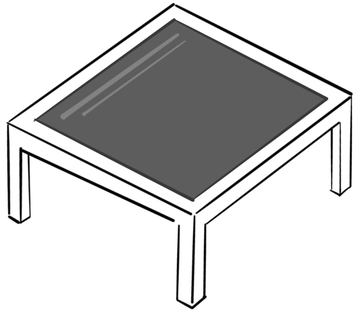
tangible tabletop



actuated tabletop



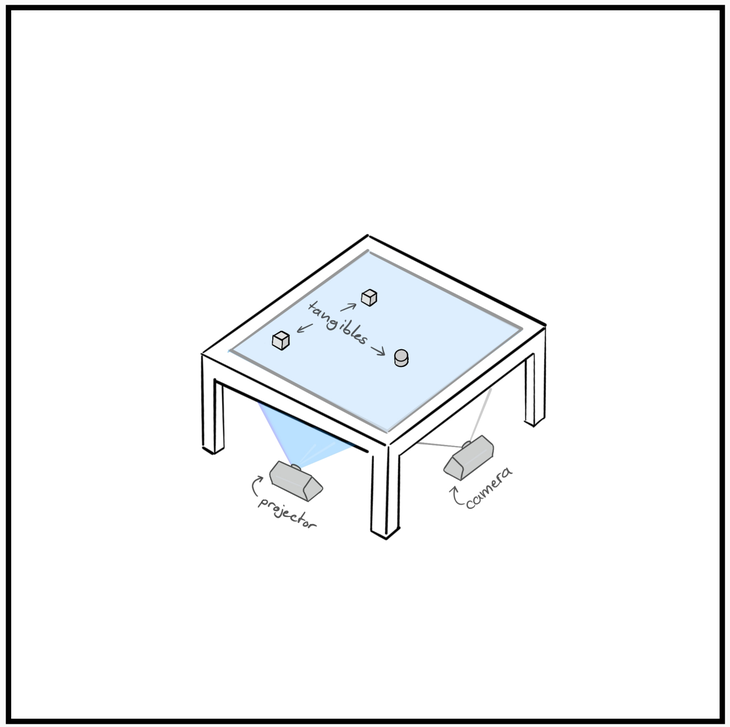
digital tabletop



example

Microsoft Surface + PixelSense (2008)

tangible tabletop



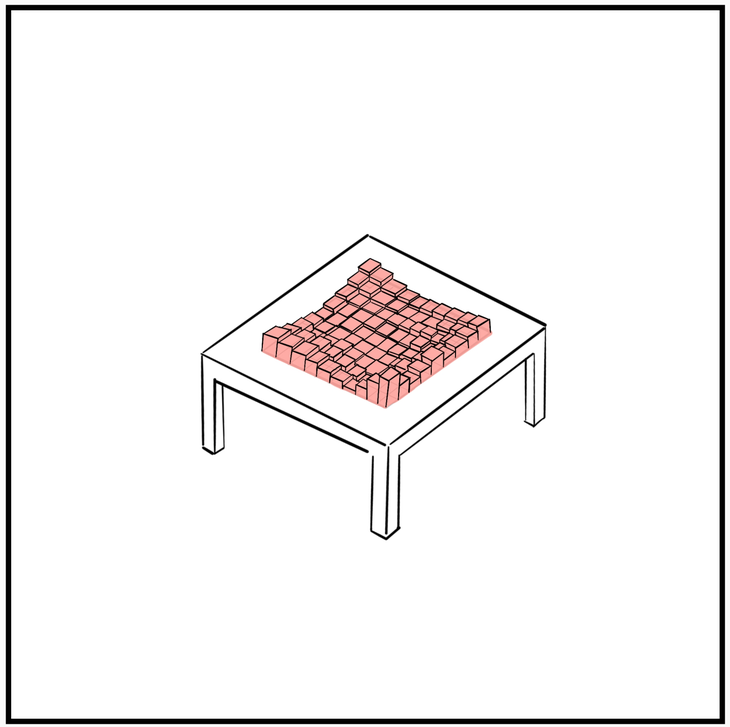
example

reacTable (Jordà et al. , 2007)

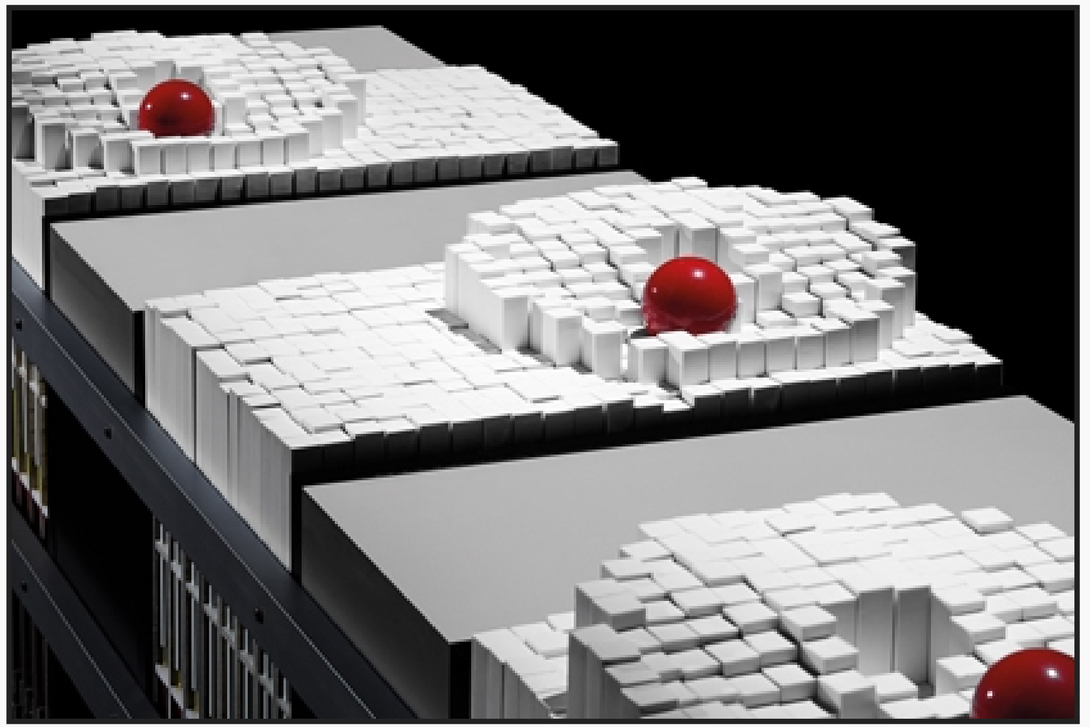
Video: https://youtu.be/0h-RhyopUmc

Paper: Jordà, S., Geiger, G., Alonso, M., & Kaltenbrunner, M. (2007, February). The reacTable: exploring the synergy between live music performance and tabletop tangible interfaces. In Proceedings of the 1st international conference on Tangible and embedded interaction (pp. 139-146).

actuated tabletop



example



TRANSFORM (Ishii et al., 2015)

Video: https://youtu.be/ICARHatJQJA

Paper: Ishii, H., Leithinger, D., Follmer, S., Zoran, A., Schoessler, P., & Counts, J. (2015, April). TRANSFORM: Embodiment of" Radical Atoms" at Milano Design Week. In Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems (pp. 687-694).

previous reviews on interactive tables focus on interaction with the tabletop [1,2,3]

we see an increasing amount of research on **shape-changing interfaces** [4] and **robotic furniture** [5].
-> new type of interactive table: **actuated table**

[1] Bellucci, A., Malizia, A., & Aedo, I. (2014). Light on horizontal interactive surfaces: Input space for tabletop computing. ACM Computing Surveys (CSUR), 46(3), 1-42.

[2] Kunz, A., & Fjeld, M. (2010). From Table–System to Tabletop: Integrating Technology into Interactive Surfaces. Tabletops-Horizontal Interactive Displays, 51-69.

[3] zum Hoff, T., Großkopp, S., Neuhaus, R., Hassenzahl, M., & Mirjam Lilith Vincent, M. (2022, February). Interactive tables for social experiences at home. In Sixteenth International Conference on Tangible, Embedded, and Embodied Interaction (pp. 1-12).

[4] Jason Alexander, Anne Roudaut, Jürgen Steimle, Kasper Hornbæk, Miguel Bruns Alonso, Sean Follmer, and Timothy Merritt. 2018. Grand Challenges in Shape-Changing Interface Research. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). Association for Computing Machinery, New York, NY, USA, Paper 299, 1–14. https://doi.org/10.1145/3173574.3173873

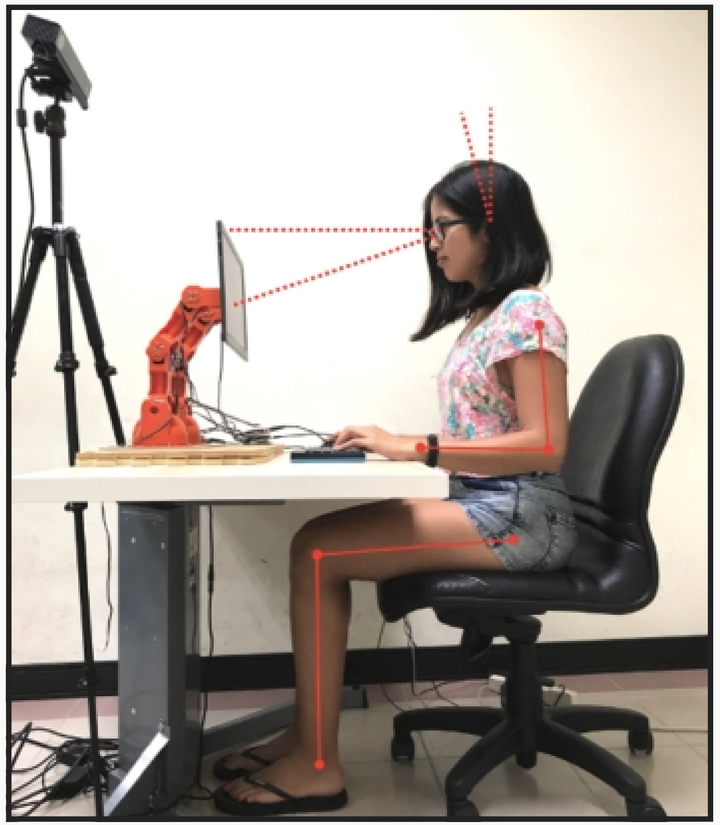
[5] Sirkin, D., Mok, B., Yang, S., & Ju, W. (2015, March). Mechanical ottoman: how robotic furniture offers and withdraws support. In Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction (pp. 11-18).

actuated tables

table-like interfaces that can kinetically change physical shape, position, composition, orientation, and location

example

ActiveErgo



Wu, Y. C., Wu, T. Y., Taele, P., Wang, B., Liu, J. Y., Ku, P. S., ... & Chen, M. Y. (2018, April). Activeergo: Automatic and personalized ergonomics using self-actuating furniture. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (pp. 1-8).

example

KirigamiTable

Video: https://youtu.be/sEQYKRLKJV0

Grønbæk, J. E., Rasmussen, M. K., Halskov, K., & Petersen, M. G. (2020, April). KirigamiTable: Designing for proxemic transitions with a shape-changing tabletop. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1-15).

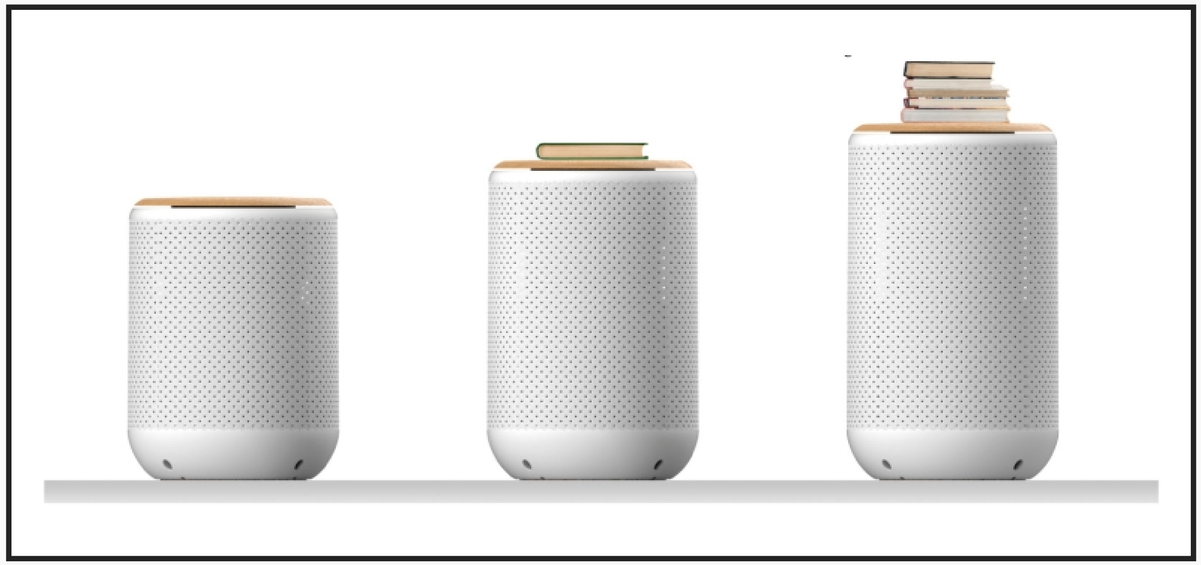
example

table-non-table

Hauser, S., Wakkary, R., Odom, W., Verbeek, P. P., Desjardins, A., Lin, H., ... & De Boer, G. (2018, April). Deployments of the table-non-table: A Reflection on the Relation Between Theory and Things in the Practice of Design Research. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (pp. 1-13).

example

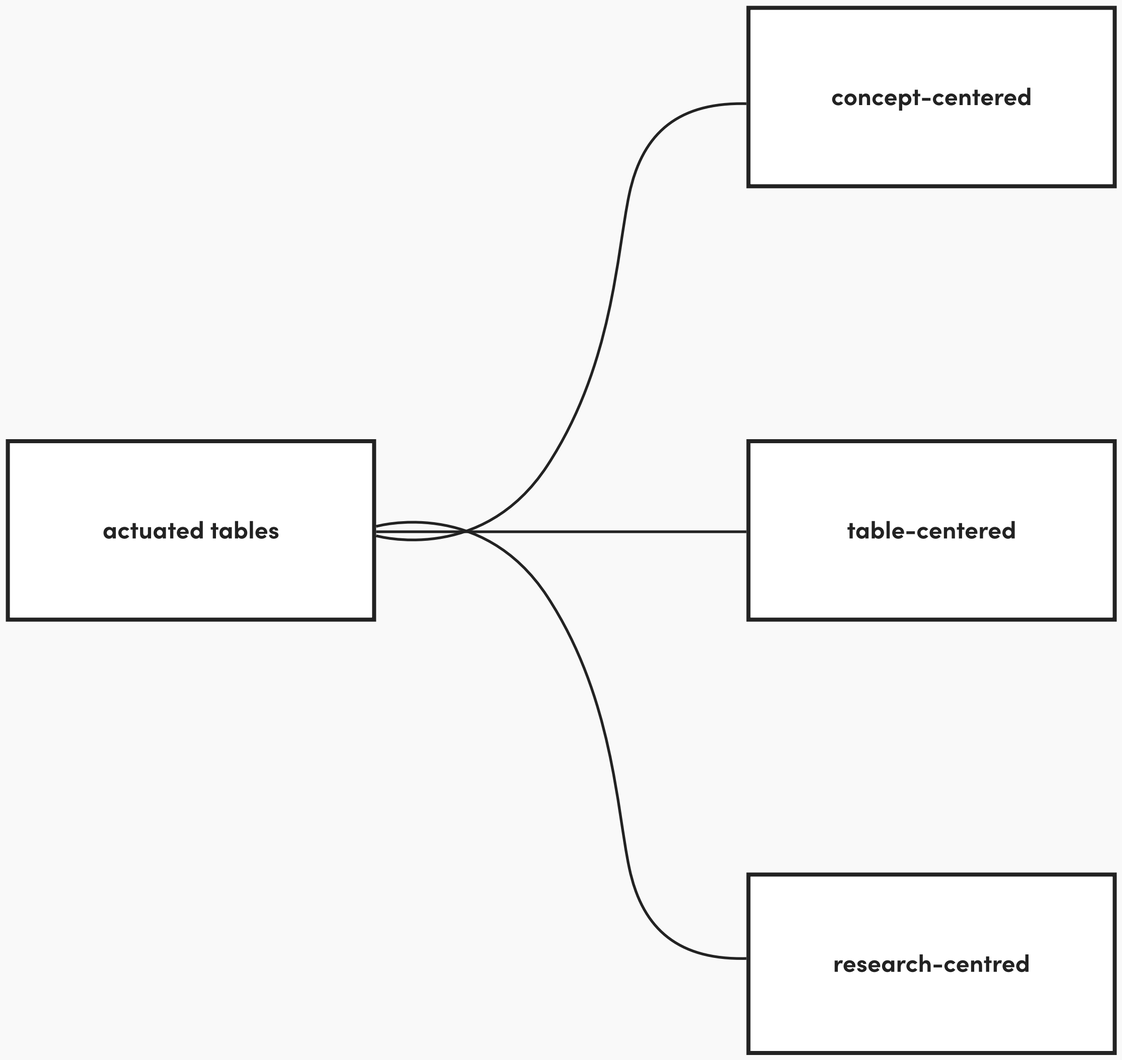
deformTable



Zhong, C., Wakkary, R., Chen, A. Y. S., & Oogjes, D. (2021, June). deformTable: Crafting a Shape-changing Device for Creative Appropriations Over Time. In Designing Interactive Systems Conference 2021 (pp. 1253-1265).

goal

create an overview of the current state of actuated table designs



application
what is the intended purpose behind the table design?

context
who is the table designed for and in what environment is the table situated?

single or multiple user(s)
is the table designed with a single or multiple users in mind?

actuation form
what actuation capabilities does the table posses - how can it change its form?

interaction modalities
how does the table sense its environment and what does it actuate?
(input / output)

aesthetic motivations
are the aesthetics of the table design explicitly mentioned and motivated?

research approach
how does the table design generate new knowledge?
(lab, field)

degree of independence
to what extent is the table developed to operate independently?
(autonomous, wizard of oz)

method

source
ACM library in the last decade

key words
“table”, “tabletop”, “design*”, and “interact*”

exclusion criteria
+ focus on design concept with a prototype
+ full-papers, demo reports, extended abstracts
- no actuated interfaces separate from the table
- no duplicate papers reporting on the same design
- no papers focusing merely on technical implementation

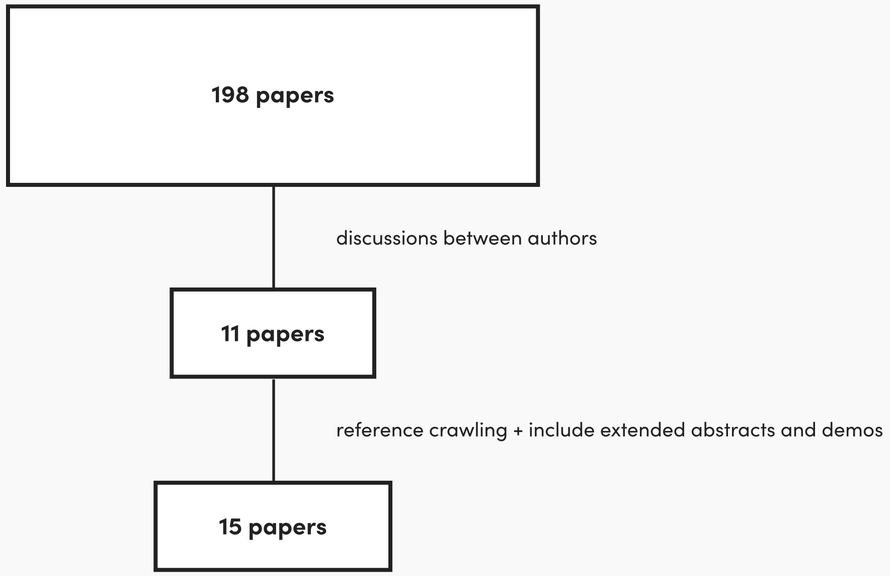


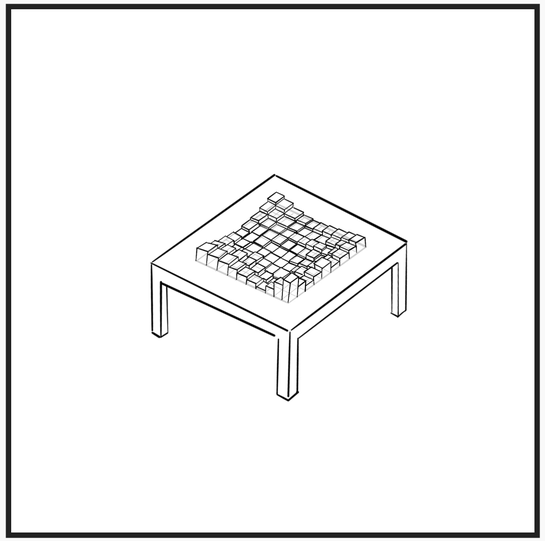
Table 2: An overview of the gathered data set on actuated tables, covering concept-centered, table-centered, and research-centered attributes.

	Concept-centered														Table-centered						Research-centered						
	Application					Setting							User(s)		Actuation Form						Approach			Independence			
	Collaboration	Ergonomics	Healthcare	Inquiry-driven	Social	Dining	Healthcare	Home	Work	Generic	Indoor	Outdoor	Single	Multiple	Actu. Tabletop	Mobile	Height-change	Shape-change		Aesthetics	RtD		Lab	Field	Autonomous	Wizard of Oz	
[49] **DeformTable**	○	○	○	●	○	○	○	●	○	○	●	○	-	-	○	○	●	○		●	●		○	●	●	○	
[9] **KirigamiTable**	●	○	○	○	○	○	○	○	●	○	●	○	○	●	○	○	○	●		●	●		-	-	-	-	
[7] **TurnTable**	●	○	○	○	●	/					●	○	○	●	●	○	○	○		○	○		-	-	-	-	
[23] **SociaBowl**	●	○	○	○	●	/					●	○	○	●	●	○	○	○		○	○		-	-	-	-	
[20] **Auto-Desk**	○	●	○	○	○	○	○	○	●	○	●	○	●	○	○	○	●	○		○	○		●	○	○	●	
[17] **AdapTable**	○	●	○	○	○	○	○	○	●	○	●	○	●	○	○	●	○	○		○	○		●	○	●	○	
[28] **ActuEating**	○	○	○	○	●	●	○	○	○	○	●	○	○	●	●	○	○	○		●	●		○	●	●	○	
[46] **ActiveErgo**	○	●	○	○	○	○	○	○	●	○	●	○	●	○	○	○	●	○		○	○		●	○	●	○	
[42] **Interactive Interior**	○	○	●	○	○	○	●	○	○	○	●	○	○	●	●	○	○	○		○	●		○	●	●	○	
[11] **Table-non-table**	○	○	○	●	○	○	○	●	○	○	●	○	-	-	○	●	○	○		●	●		○	●	●	○	
[8] **Proxemic-Trans**	●	○	○	○	○	○	○	○	●	○	●	○	○	●	○	○	○	●		○	●		-	-	-	-	
[24] **Eating Together**	○	○	○	○	●	●	○	○	○	○	/		○	●	●	○	○	○		○	○		-	-	-	-	
[41] **MovemenTable**	●	○	○	○	○	○	○	○	●	○	●	○	○	●	○	●	○	○		○	○		●	○	○	●	
[43] **ART**	○	○	●	○	○	○	●	○	○	○	●	○	○	●	●	○	●	○		○	●		○	●	/		
[40] **TransformTable**	●	○	○	○	○	○	○	○	○	●	●	○	○	●	○	○	○	●		○	○		●	○	/		

Legend: ● = yes, ○ = no, - = not applicable, / = not specified.
Please refer to Section 3.2 for a summary of the Interaction Modalities

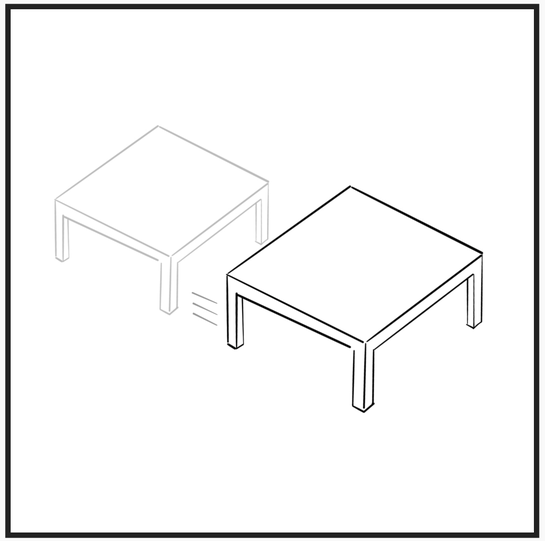
actuation forms
the various styles of movement found in actuated tables

actuated tabletop



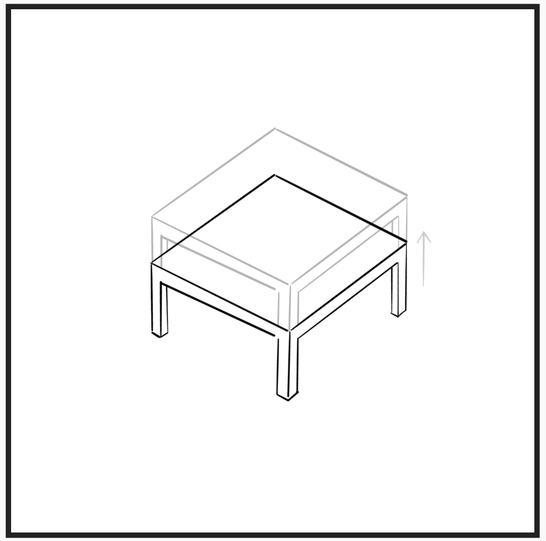
sociaBowl [23]

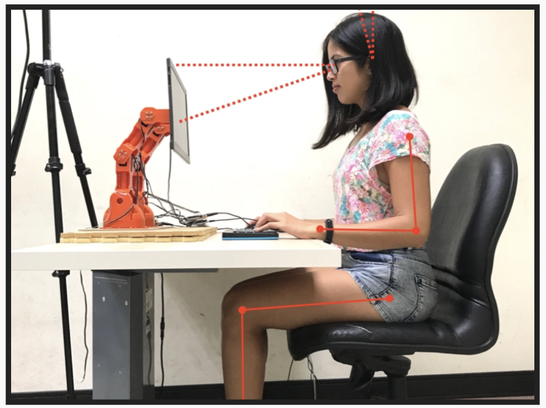
mobile



movemenTable [41]

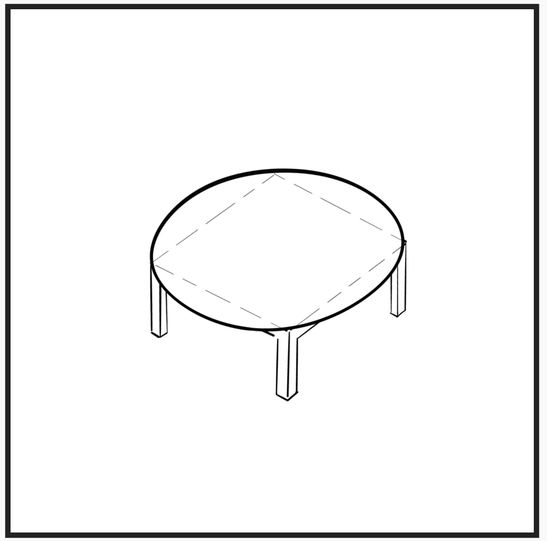
height-change





activeErgo [46]

shape-change



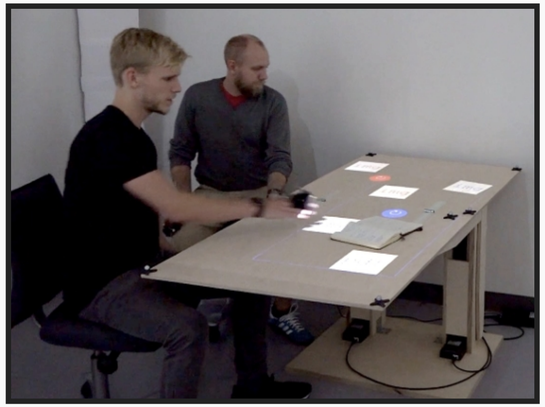
kirigamiTable [9]

discussion qualities of actuated tables

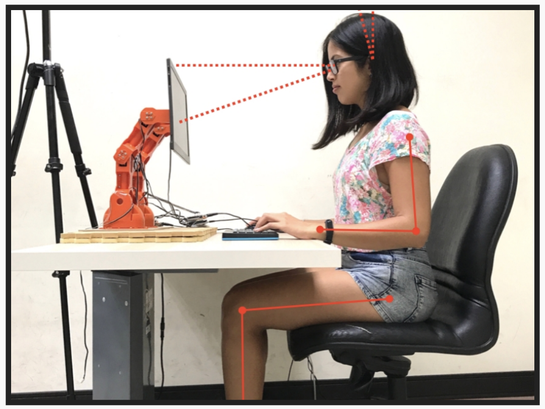
adaptability
adapting to the user, environment, task at hand

flexibility
positioning in the environment, multi-purpose tables

social mediation
actuation gives agency to the table to serve as a social mediator



Proxemic Transitions [8]



activeErgo [46]

turnTable [7]

discussion potential for more applications

relatively narrow scope of applications
collaboration
ergonomics
healthcare
inquiry-driven
social mediation

opportunities
gaming
playful applications
accessibility
educational

	Concept-centered													
	Application					Setting					User(s)			
	Collaboration	Ergonomics	Healthcare	Inquiry-driven	Social	Dining	Healthcare	Home	Work	Generic	Indoor	Outdoor	Single	Multiple
[49] **DeformTable**	○	○	○	●	○	○	○	●	○	○	●	○	-	-
[9] **KirigamiTable**	●	○	○	○	○	○	○	○	●	○	●	○	○	●
[7] **TurnTable**	●	○	○	○	●	/					●	○	○	●
[23] **SociaBowl**	●	○	○	○	●	/					●	○	○	●
[20] **Auto-Desk**	○	●	○	○	○	○	○	○	●	○	●	○	●	○
[17] **AdapTable**	○	●	○	○	○	○	○	○	●	○	●	○	●	○
[28] **ActuEating**	○	○	○	○	●	●	○	○	○	○	●	○	○	●
[46] **ActiveErgo**	○	●	○	○	○	○	○	○	●	○	●	○	●	○
[42] **Interactive Interior**	○	○	●	○	○	○	●	○	○	○	●	○	○	●
[11] **Table-non-table**	○	○	○	●	○	○	○	●	○	○	●	○	-	-
[8] **Proxemic-Trans**	●	○	○	○	○	○	○	○	●	○	●	○	○	●
[24] **Eating Together**	○	○	○	○	●	●	○	○	○	○	/		○	●
[41] **MovemenTable**	●	○	○	○	○	○	○	○	●	○	●	○	○	●
[43] **ART**	○	○	●	○	○	○	●	○	○	○	●	○	○	●
[40] **TransformTable**	●	○	○	○	○	○	○	○	○	●	●	○	○	●

discussion actuated tables in the outdoors

no tables for the outdoor settings yet
could be due to practical limitations

opportunities
public spaces, e.g. parks, bus stops

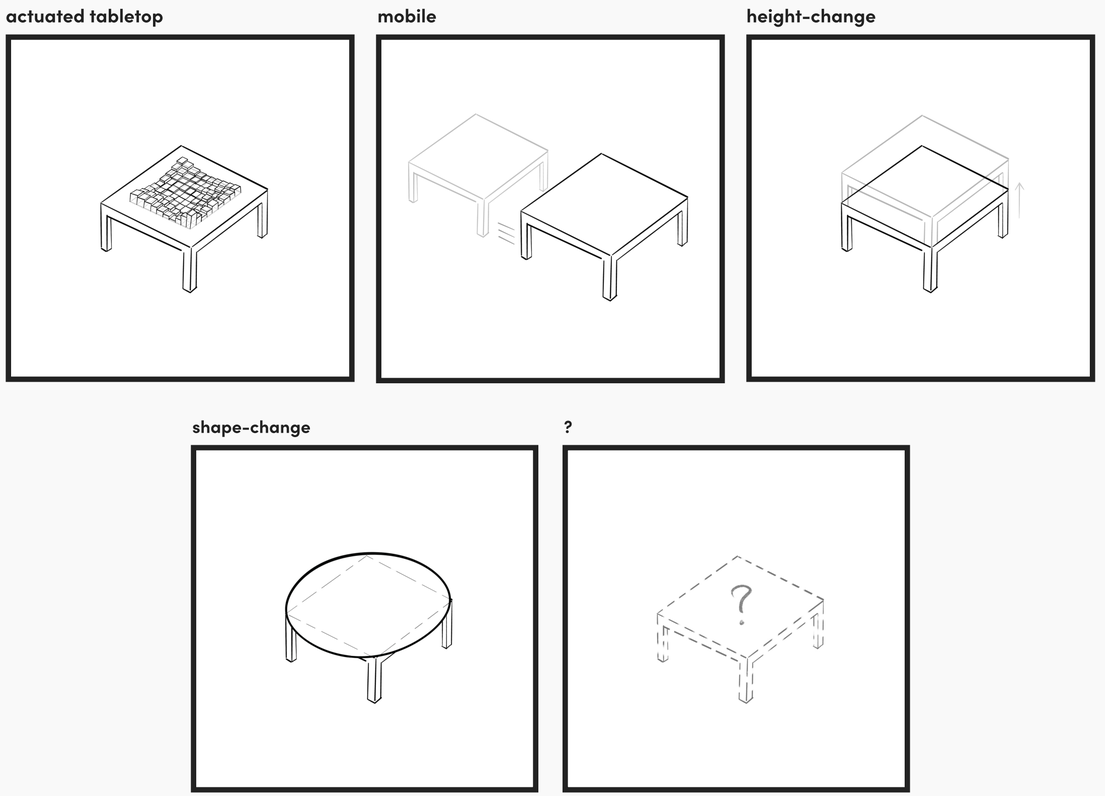
Herben et al., 2023

	Concept-centered														
	Application					Setting							User(s)		
	Collaboration	Ergonomics	Healthcare	Inquiry-driven	Social	Dining	Healthcare	Home	Work	Generic	Indoor	Outdoor	Single	Multiple	
[49] **DeformTable**	○	○	○	●	○	○	○	●	○	○	●	○	-	-	
[9] **KirigamiTable**	●	○	○	○	○	○	○	○	●	○	●	○	○	●	
[7] **TurnTable**	●	○	○	○	●	/					●	○	○	●	
[23] **SociaBowl**	●	○	○	○	●	/					●	○	○	●	
[20] **Auto-Desk**	○	●	○	○	○	○	○	○	●	○	●	○	●	○	
[17] **AdapTable**	○	●	○	○	○	○	○	○	●	○	●	○	●	○	
[28] **ActuEating**	○	○	○	○	●	●	○	○	○	○	●	○	○	●	
[46] **ActiveErgo**	○	●	○	○	○	○	○	○	●	○	●	○	●	○	
[42] **Interactive Interior**	○	○	●	○	○	○	●	○	○	○	●	○	○	●	
[11] **Table-non-table**	○	○	○	●	○	○	○	●	○	○	●	○	-	-	
[8] **Proxemic-Trans**	●	○	○	○	○	○	○	○	●	○	●	○	○	●	
[24] **Eating Together**	○	○	○	○	●	●	○	○	○	○	/		○	●	
[41] **MovemenTable**	●	○	○	○	○	○	○	○	●	○	●	○	○	●	
[43] **ART**	○	○	●	○	○	○	●	○	○	○	●	○	○	●	
[40] **TransformTable**	●	○	○	○	○	○	○	○	○	●	●	○	○	●	

discussion actuation forms

we found four types of actuation
these are by no means complete
limited sample size of 15 designs

further research
what other forms of actuation are there?
what use cases are there for each form?



discussion expressivity through actuation

we found two examples with motion design

can we utilise the movement of the actuation as a resource for design?

speed, acceleration, direction

communicating intentions of the table – body language
also aesthetic, playful, artistic, or poetic purposes

sociaBowl [23]

movemenTable [41]

key take-aways

we defined actuated tables as an interactive table with the ability to physically move itself, or a part of itself, through kinetically changing its shape, position, composition, orientation, or location

we summarised the state of actuated table designs within the last decade of research

we created an overview of concept-centered, table-centered, and research-centered attributes

we introduced four preliminary actuation forms

we found that some common qualities are their adaptability, flexibility, and social mediation

we identified gaps in current research where the potential of actuation in tables is underexplored, e.g. accessibility, gaming, and tables outdoor

we discuss how the movement of actuation can be further explored as a design resource for expressivity

what do you think?

can you think of any application areas where actuation in tables can contribute?

do you have ideas for other actuated table designs?

contact
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