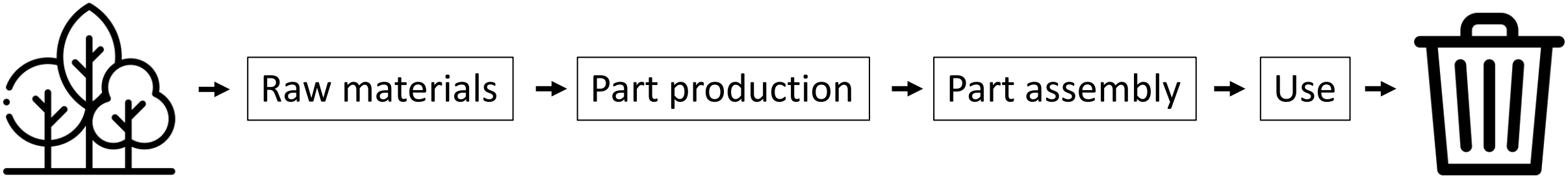
Computational *Circular* Design

Adrien Bousseau

Linear production is efficient, but wasteful



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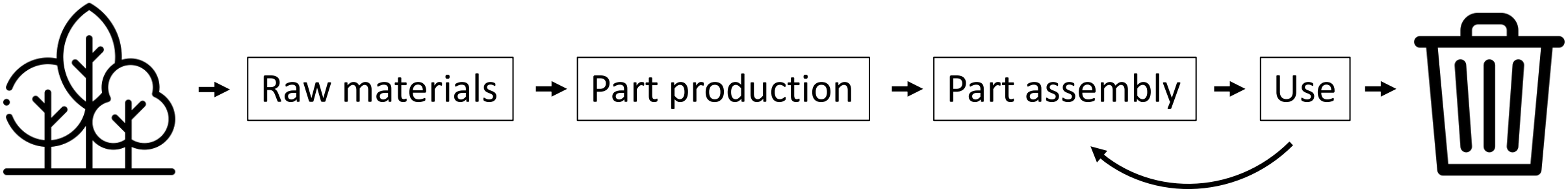
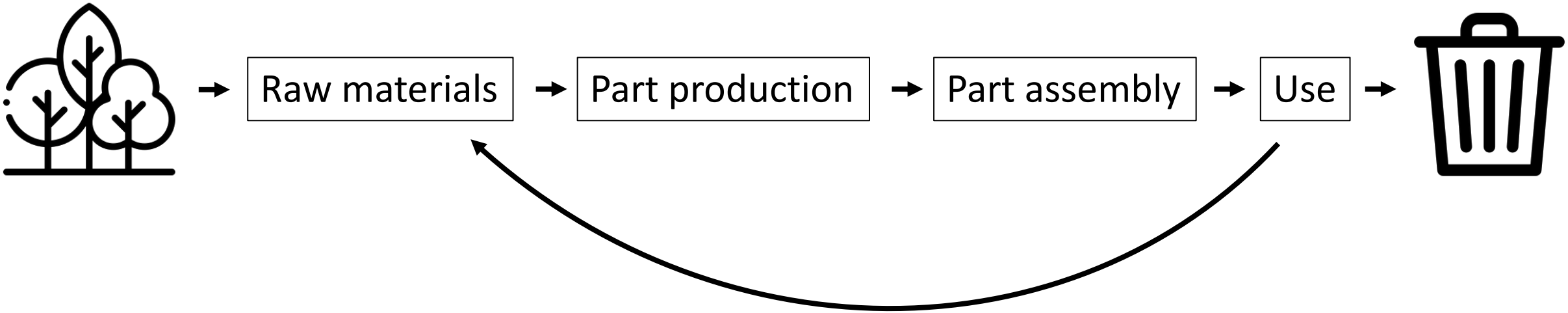


Repair

+ Extend lifetime

- Limited to same product

Linear production is efficient, but wasteful



Recycle

+ Recover material to produce new objects

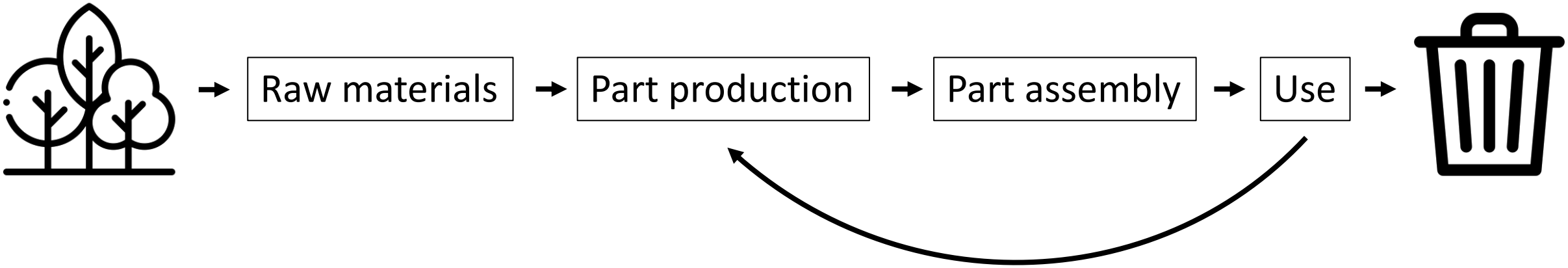
- Degrades material quality

Many materials cannot be recycled

Wind turbines will result in
40Mt of cumulative waste by 2050

30% of garments are never sold
Only 1% of clothes are recycled in new garments

Linear production is efficient, but wasteful



Structural reuse

+ Create new parts from existing objects
+ Maintain material quality

Circular design through reuse

[Superuse, Re-wind, Wings for Living]

Circular design through reuse

Design of Truss Structures Through Reuse

Jan Brütting[a,*], Joseph Desruelle[a], Gennaro Senatore[b], Corentin Fivet[a]

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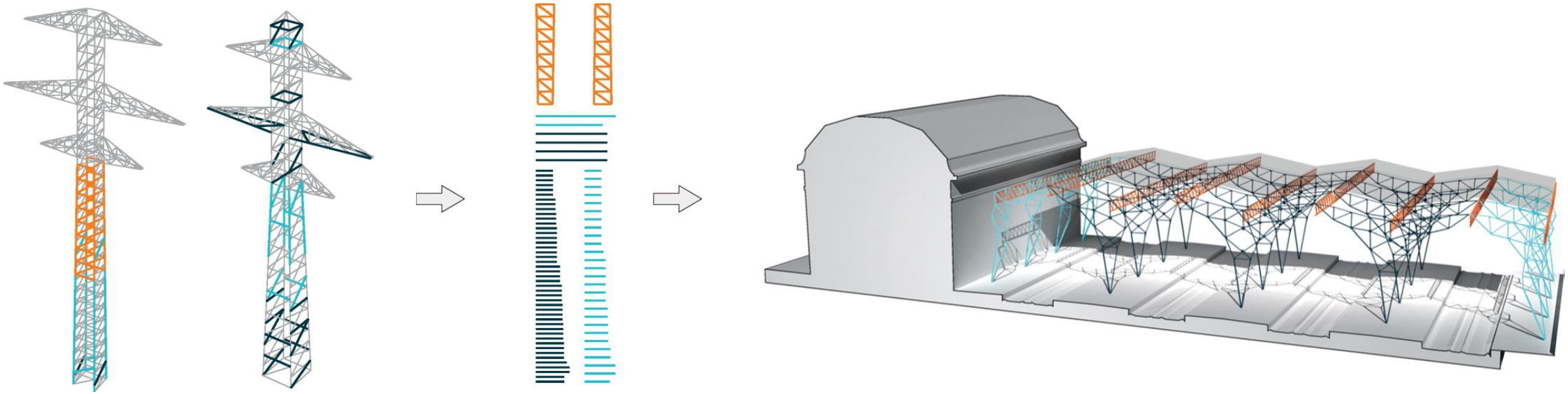
[b] *Applied Computing and Mechanics Laboratory, Swiss Federal Institute of Technology (EPFL), Station 18, 1015 Lausanne, Switzerland*



From blades to tracks:
A case study in structural reuse of curved surfaces for circular design

Jesse Pupping[1], Marzia Risso[2], Adrien Bousseau[2], Mariana Popescu[1], Jelle Joustra[1]

ACM SCF 2025

1 TU Delft

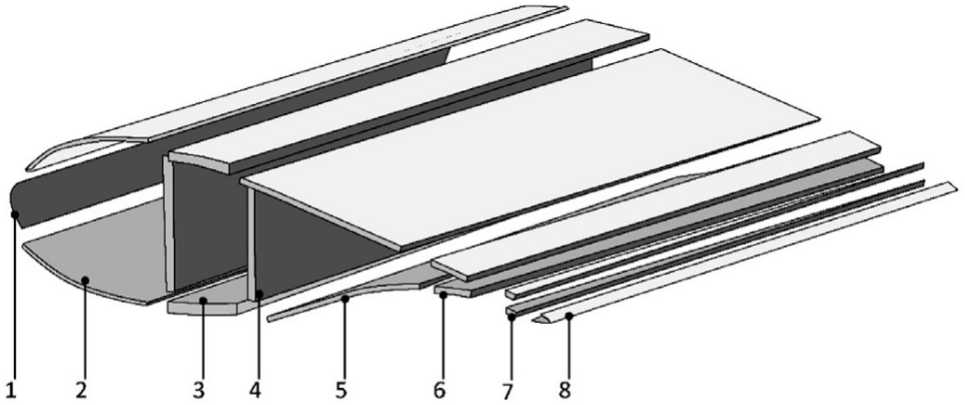
2 Inria UNIVERSITÉ CÔTE D'AZUR

Structural reuse of wind turbine blades through segmentation

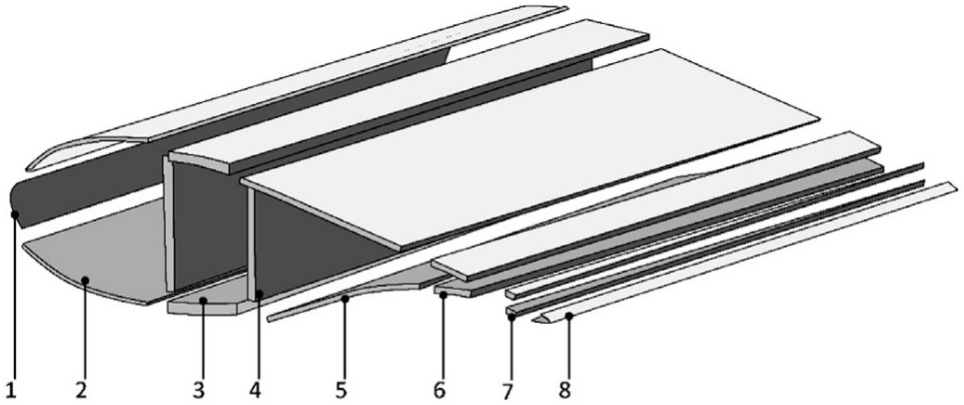
Jelle Joustra*, Bas Flipsen, Ruud Balkenende

Faculty of Industrial Design Engineering, Delft University of Technology, Delft 2628 CE, the Netherlands

- Demonstrate a plausible reuse scenario
- Focus on flat parts of the blade (55% of reuse)



Extension to curved structures?



Freeform architecture

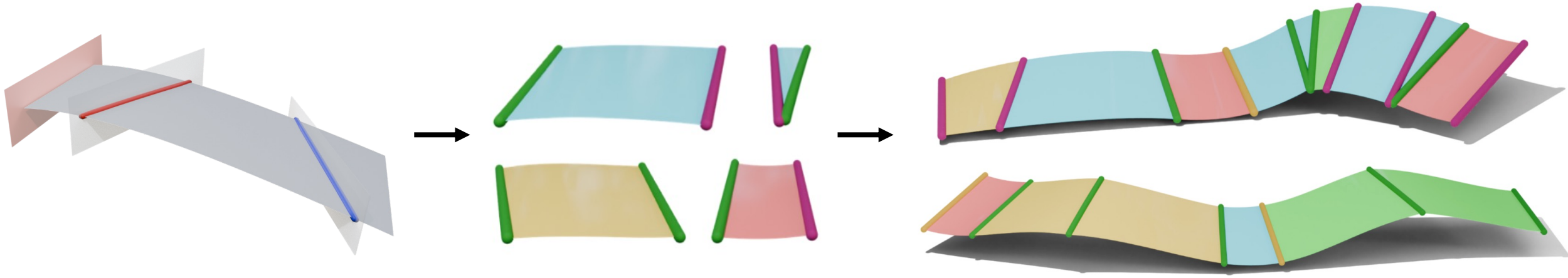
Sport equipment

Case study: pump track modules

- Acquire segments of a decomissioned wind turbine blade
- Identify panels with similar curvature as pump track modules
- Cut and assemble two modules, test with practitioners

CAD tool for pump track design

- Extract modular panels
- Optimize cuts to maximize continuity at panel boundaries
- Chain panels with compatible boundaries to create tracks



Automatic cut selection

Identification of compatible modules

Assembly of diverse tracks

Shape Approximation by Surface Reuse

Berend Baas[1], David Bommes[2], Adrien Bousseau[1]

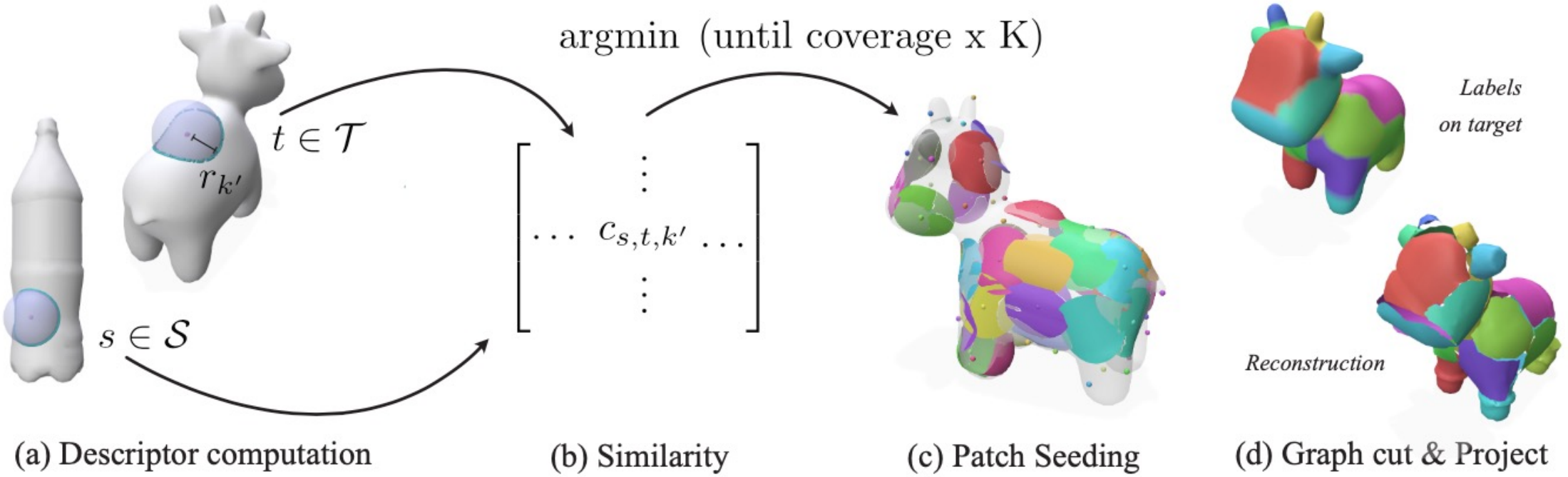
SGP 2025

[1] Inria UNIVERSITÉ CÔTE D'AZUR

[2] UNIVERSITÄT BERN

Partial matching between different shapes

- Joint segmentation (**discrete**) and registration (**continuous**)
- Initialize by matching local descriptors
- Propagate good matches using graph cut



Shape approximation by reuse

(a) Source

(b) Target

(c) Reconstruction

(d) Fabricated Result

Rags2Riches: Computational Garment Reuse

Anran Qi[1], Nico Pietroni[2], Maria Korosteleva[3], Olga Sorkine-Hornung[3], Adrien Bousseau[1]

SIGGRAPH 2025

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Principles of garment reuse

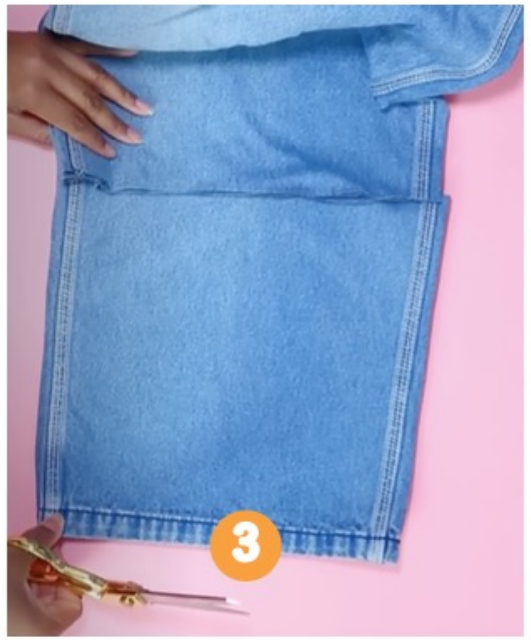
[Portia Lawrie. 2023. The Re:Fashion Wardrobe]

MOST REQUESTED DIY!! Upcycle Jeans into DOPE Denim Tank - By Orly Shani

https://www.youtube.com/watch?v=ho0b1dHqQcU&t=8s

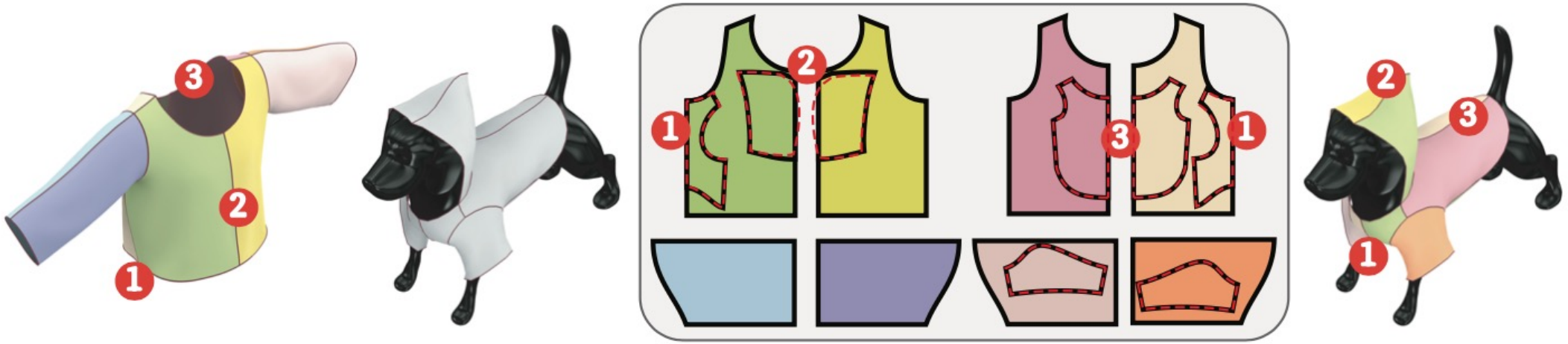
Principles of garment reuse

- Reuse of valuable structures (seams, hems)
- Adaptation to available components
- Preservation of grain orientation



Problem formulation

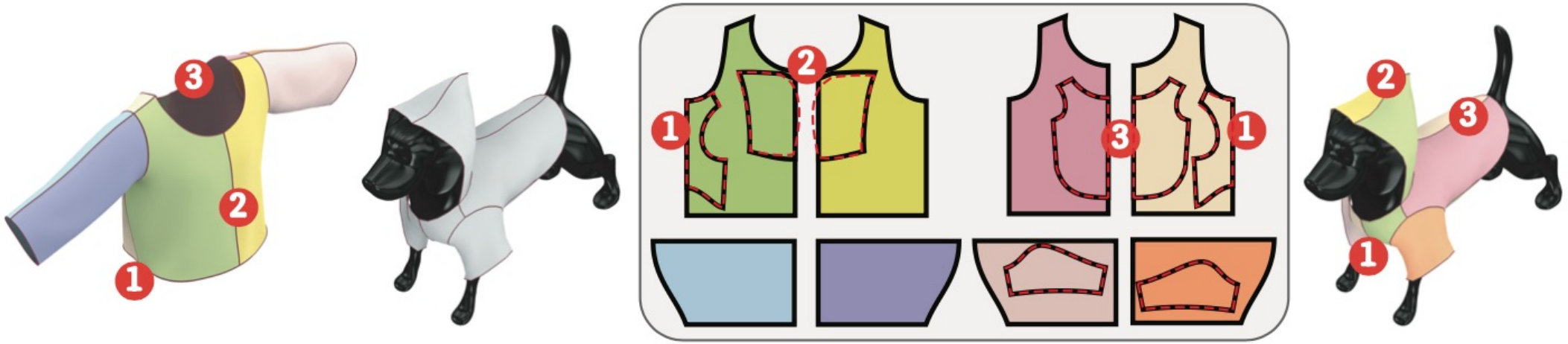
- Assume we have the garment patterns as input
- Find where to place the target patterns on the source
- Maximize reuse of seams and hems
- Minimize panel deformation



(a) Source (b) Target (c) Reused pattern (d) Result

Problem formulation

- Assume we have the garment patterns as input
- Find where to place the target patterns on the source **– continuous**
- Maximize reuse of seams and hems **– discrete**
- Minimize panel deformation **– continuous**



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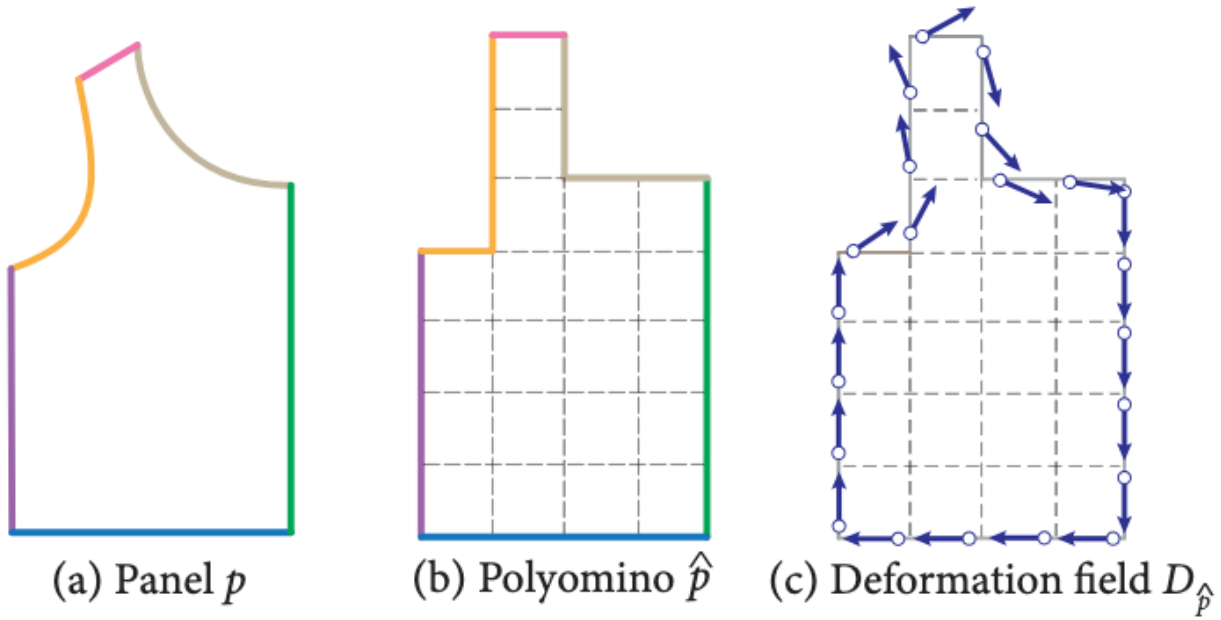
Our approach

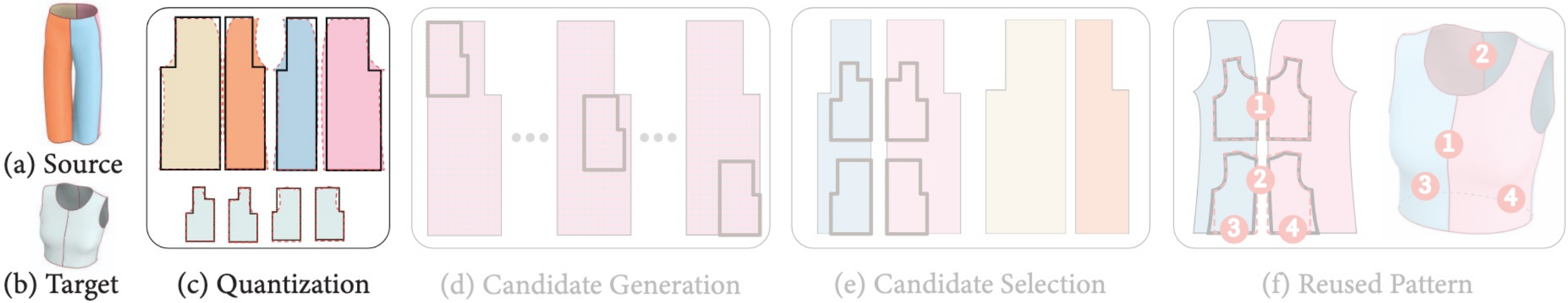
- Descretize the search space by quantizing the panels
- Model quantization error via a deformation field



(a) Panel p (b) Polyomino $\hat{p}$ (c) Deformation field $D_{\hat{p}}$

Our approach

- Descretize the search space by quantizing the panels
- Model quantization error via a deformation field
- Generate candidate placements by sliding window
- Select best placements by solving assignment problem



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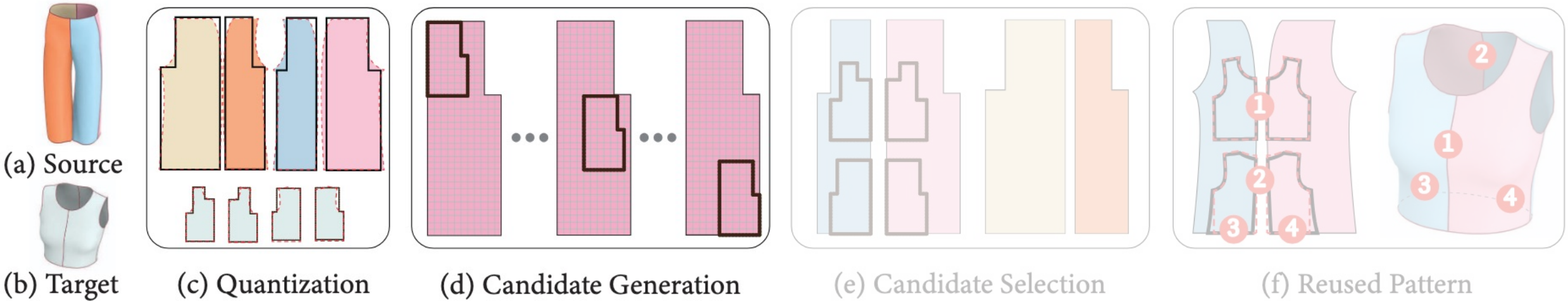

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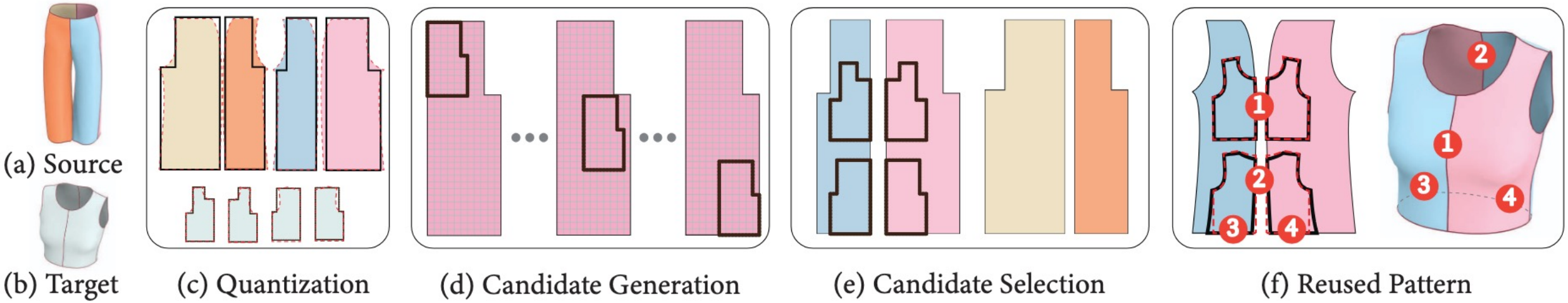
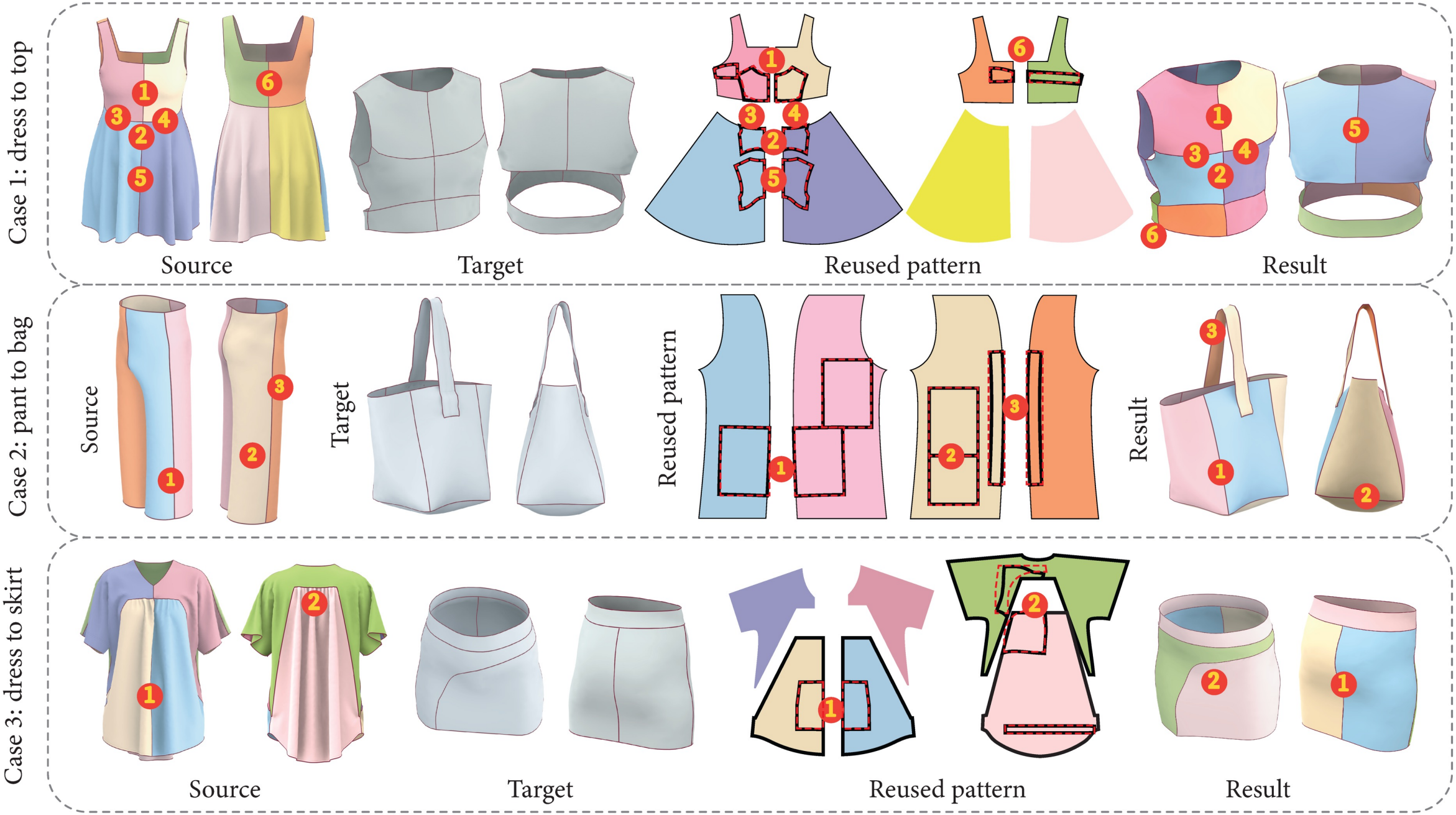
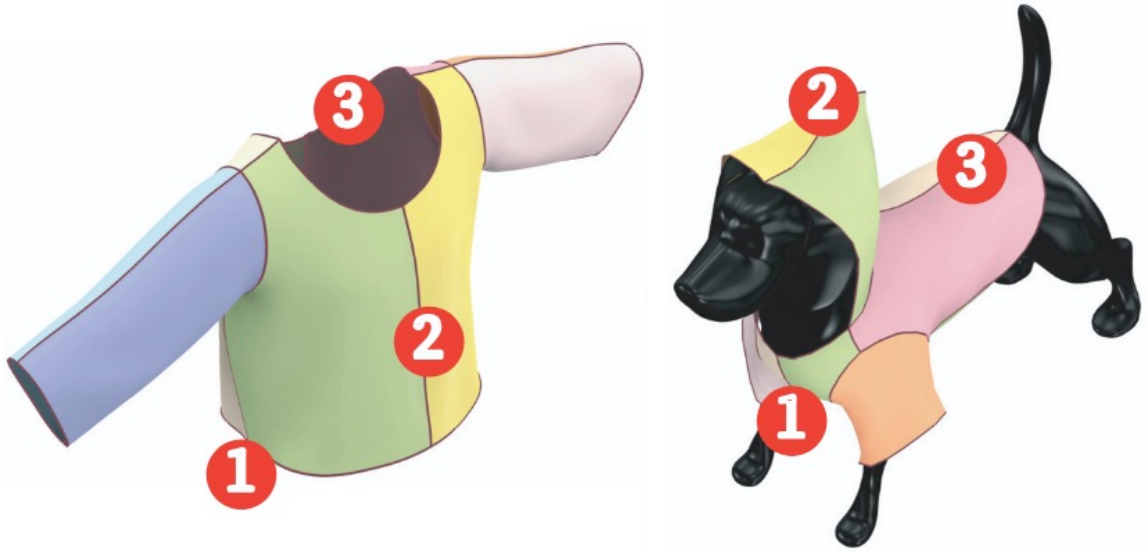



Case 1: dress to top
Source
Target
Reused pattern
Result
Case 2: pant to bag
Source
Target
Reused pattern
Result
Case 3: dress to skirt
Source
Target
Reused pattern
Result

Real-world prototype



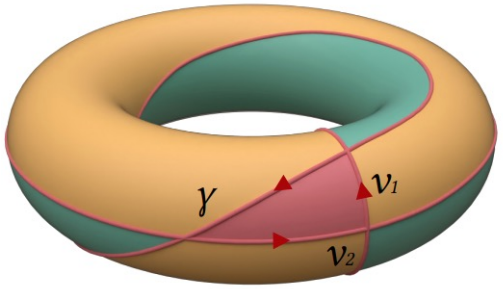
Conclusion and future work

Insights gained on reuse of surfaces

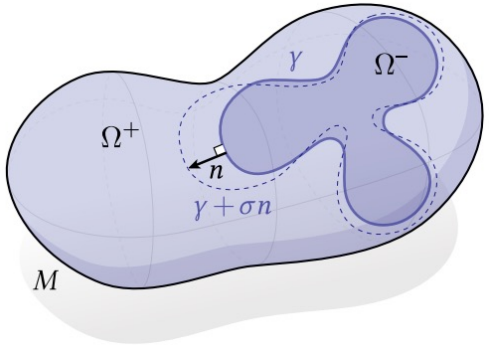
- Challenging geometric optimization problems
  - Joint segmentation and assignment
  - Combinatorial design space
- Constrained by available stock, as well as by manufacturing processes

Next steps

- Algorithmic foundations to represent and optimize cuts and assembly



Arrangements on surfaces
[Riso et al. 2022]



Variational cuts
[Sharp and Crane 2018]

- Scalable search strategies

Diffusion for assembly
[Scarpellini et al. 2024]