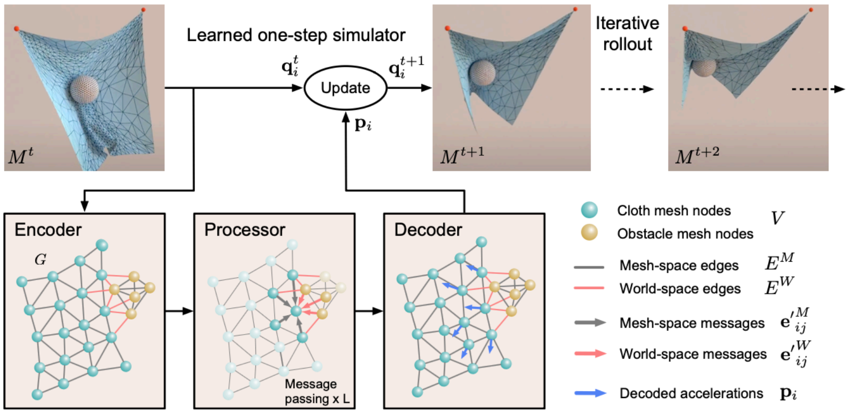
Report on the state of the art on the subject:

Physics-based Simulation of Deformable Objects with Deep Learning for Computer Graphics Applications

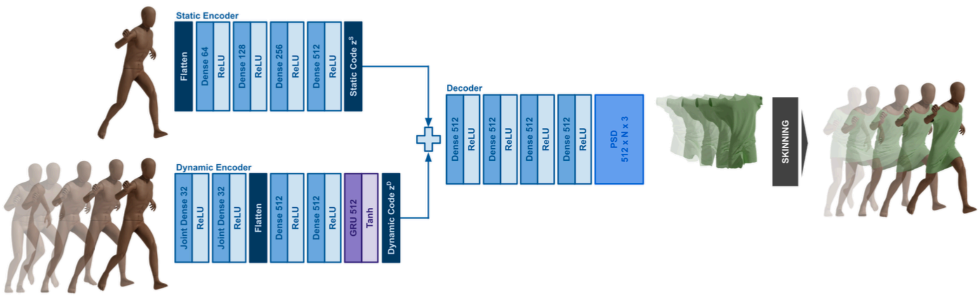
GRANADOS Antonin Parcours Recherche 15/01/2026

- **MeshGraphNet** (2021) [PDF] T. Pfaff, M. Fortunato, A. Sanchez-Gonzalez, and P. W. Battaglia [1]
  - /!\ Remeshing can be very slow
  - /!\ Using a uniform mesh that is too coarse (to make it comparable to the remeshed version) removes a lot (maybe too much) detail on the cloth [video 1] [video 2]
  - /!\ The fixed number of message passing layers can't process long-range interactions



[demo 1 (~150 epochs)] [demo 2 (~700 epochs)]

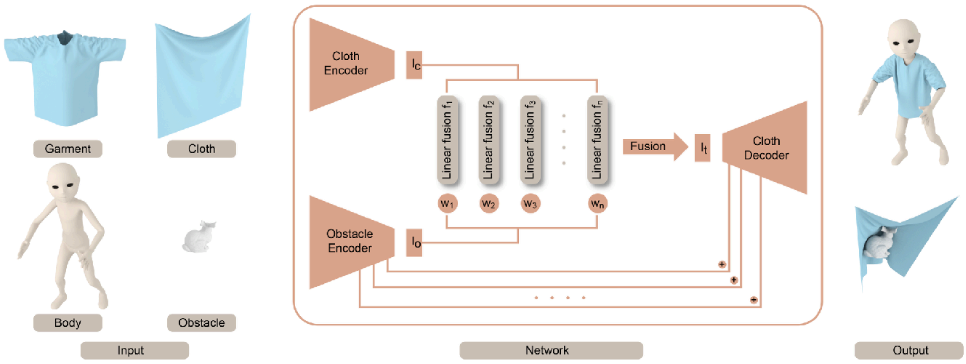
- **Neural Cloth Simulation** (2022) [PDF] H. Bertiche, M. Madadi, and S. Escalera [2]
  - Introduces *unsupervised learning* inspired by physical cloth simulation.
  - *Disentangles* cloth subspace (ie. encode static / dynamic features)
  - Gives the model position (bones features) as input and predicts cloth nodes offsets on a static pose ("T-pose") then *skins* the predicted cloth onto the model.
  - /!\ Uses "skeleton-based human body models" → fixed model/obstacle shape
  - /!\ The cloth has a fixed node count because of the output size



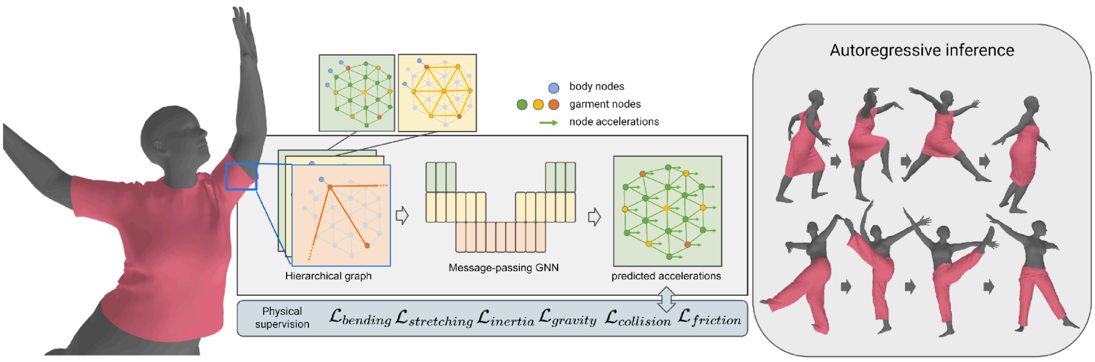
- **N-Cloth: Predicting 3D Cloth Deformation with Mesh-Based Networks** (2022) [PDF] Y. Li *et al.* [3]
  - Uses a *mesh-based approach* (like T. Pfaff, M. Fortunato, A. Sanchez-Gonzalez, and P. W. Battaglia [1] and not a skeleton like H. Bertiche, M. Madadi, and S. Escalera [2])
  - Add a model-cloth and self penetration *physical loss*
  - Does most of the computation on a *latent space* (like most other work) and directly predicts the new nodes positions
  - Uses Graph Convolutional Networks (GCNs) to encode the cloth/body meshes:

$$X^{l+1} = \sigma\left(\tilde{D}^{-\frac{1}{2}}\tilde{A}^{(l)}\tilde{D}^{-\frac{1}{2}}X^{(l)}W^{(l)}\right) , \qquad \tilde{A}^{(l)} = A^{(l)} + I \ , \ \tilde{D}_{ii} = \sum_j \tilde{A}_{ij}$$

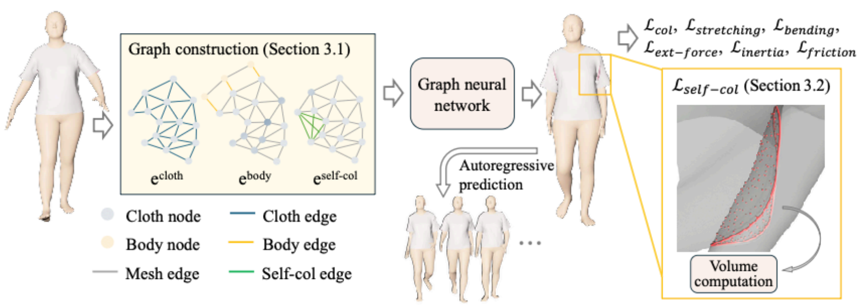
  - /!\ The output size depends on the node count (the size of the mesh is fixed by the draining data)



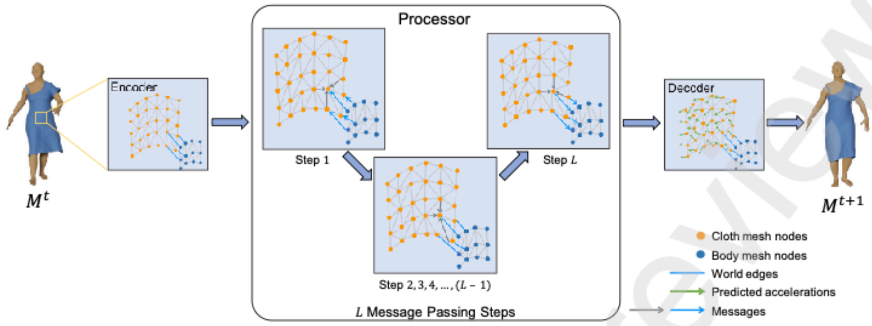
- **HOOD: Hierarchical Graphs for Garment Dynamics** (2023) [PDF] A. Grigorev, M. J. Black, and O. Hilliges [4]
  (Github: https://github.com/dolorousrtur/hood)
  - Their model is closely related to T. Pfaff, M. Fortunato, A. Sanchez-Gonzalez, and P. W. Battaglia [1] (but they try to solve the issue of slow message passing and hyperparameters that are difficult to tune)
  - Uses *unsupervised learning* to predict node accelerations
  - Uses a mesh-based approach → the method is *agnostic to the body shape*
  - Uses a *multi-level message passing architecture* (similar multi-scale graph as in X-MeshGraphNet M. A. Nabian, C. Liu, R. Ranade, and S. Choudhry [5]) to accelerate signal propagation & Add *physical features* to the nodes/edges
  - Limitations given by the authors:
    - /!\ There is no self-collision handling (adding edges to represent self-collisions would become computationally expensive)
    - /!\ The model fails with motion not seen during training (ex: too fast) → continuous collision detection ?
    - /!\ (Does not work with self intersecting body, but this is not really a problem from them)

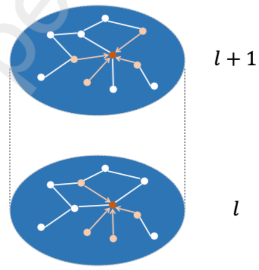


- **SENC: Handling Self-collision in Neural Cloth Simulation** (2024) [PDF] Z. Liao, S. Wang, and T. Komura [6]
  - Uses a *self-supervised* model
  - The network is based on MeshGraphNet (T. Pfaff, M. Fortunato, A. Sanchez-Gonzalez, and P. W. Battaglia [1]) and the loss for the training is based on HOOD (A. Grigorev, M. J. Black, and O. Hilliges [4]) but they add a *self-collision term*
  - They compare their results mostly with HOOD (A. Grigorev, M. J. Black, and O. Hilliges [4]) which said that simply adding self-collision edges would be computationally expensive



- **FastClothGNN: Efficient GNN for Real-Time Cloth Simulation** (2024) [PDF] Y. Zhang, K. Yu, and X. Zhang [7]
  - Is focused on *real-time applications*
  - Uses *unsupervised learning* with the loss function from HOOD (A. Grigorev, M. J. Black, and O. Hilliges [4])
  - Uses the exact architecture of MeshGraphNet (T. Pfaff, M. Fortunato, A. Sanchez-Gonzalez, and P. W. Battaglia [1]) but add *edge dropout* to "reduce redundant computations" + allows only one connection to the garment per body node
  - Limitations given by the authors (nearly the same as HOOD's):
    - /!\ It fails with high speed motions
    - /!\ It cannot handle self-collision





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