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Talmon et al. (2015) - *Manifold Learning for Latent Variable Inference in Dynamical Systems*
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Nickel and Kiela (2017) - *Poincaré Embeddings for Learning Hierarchical Representations*

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1.2 Competitive Hebbian Learning

Rumelhart and Zipser (1985) - *Feature Discovery by Competitive Learning*
Summary:

Kohonen (1990) - *The self-organizing map*

Summary: The self-organizing map (SOM) creates spatially organized intrinsic representations of features. It belongs to the category of neural networks which use "competitive learning", or "self-organization". It is a sheet-like artificial neural network in which the cells become tuned to various input patterns through an unsupervised learning process. Only a neighborhood of cells give an active response to the current input sample. The spatial location or coordinates of cells in the network correspond to different modes of the input distribution. The self-organizing map is also a form of vector quantization (VQ). The purpose of VQ is to approximate a continuous probability density function $p(\boldsymbol{x})$ of input vectors $\boldsymbol{x}$ using a finite number of codebook vectors, $\boldsymbol{m}_i$, $i = 1, 2, \dots, k$. After the "codebook" is chosen, the approximation of $\boldsymbol{x}$ involves finding the reference vector, $\boldsymbol{m}_c$ closest to $\boldsymbol{x}$. The "winning" codebook vector for sample $\boldsymbol{x}$ satisfies the following:

$$||\boldsymbol{x} - \boldsymbol{m}_c|| = \min_i ||\boldsymbol{x} - \boldsymbol{m}_i||$$

The algorithm operates by first initializing a spatial lattice of codebook elements (also called "units"), where each unit's representative is in $\boldsymbol{m}_i \in \mathbb{R}^D$ where D is the dimensionality of the input samples $\boldsymbol{x}$. The training process proceeds as follows. A random sample is selected and presented to the network and each unit determines its activation by computing dissimilarity. The unit who's codebook vector provides the smallest dissimilarity is referred to as the *winner*.

$$c(t) = \arg\min_i d(\boldsymbol{x}(t), \boldsymbol{m}_i(t))$$

Both the winning vector and all vectors within a neighborhood of the winner are updated toward the sample by

$$\boldsymbol{m}_i(t+1) = \boldsymbol{m}_i(t) + \alpha(t) \cdot h_{ci}(t) \cdot [\boldsymbol{x}(t) - \boldsymbol{m}_i(t)]$$

where $\alpha(t)$ is a learning rate which decreases over time and $h_{ci}(t)$ is a neighborhood function which is typically unimodal and symmetric around the location of the winner which monotonically decreases with increasing distance from the winner. A radial basis kernel is typically chosen for the neighborhood function as

$$h_{ci}(t) = \exp\left(-\frac{||\boldsymbol{r}_c - \boldsymbol{r}_i||^2}{2\sigma^2(t)}\right)$$

where the top expression represents the Euclidean distance between units c and i with $\boldsymbol{r}_i$ representing the 2-D location of unit i in the lattice. The neighborhood kernel's bandwidth is typically initialized to a value which covers a majority of the input space and decreases over time such that solely the winner is adapted toward the end of the training procedure.

The SOM essentially performs density estimation of high-dimensional data and represents it in a 2 or 3-D representation. At test time, the dissimilarity between each unit in the map and an input sample are computed. This dissimilarity can be used to effectively detect outliers, thus making the SOM a robust method which can provide confidence values for it's representation abilities.

In this paper, the SOM was applied to speech recognition, but made note of previous uses in robotics, control of diffusion processes, optimization problems, adaptive telecommunications, image compression, sentence understanding, and radar classification of sea-ice.

Rauber et al. (2002) - *The growing hierarchical self-organizing map: exploratory analysis of high-dimensional data*

Summary: The Growing Hierarchical Self-organizing Map (GHSOM) is an extension of the classical SOM. It is an artificial neural network with a hierarchical architecture, composed of individually growing SOMs. Layer 0 is composed of a single neuron representing the mean of the training data. A global stopping criteria is developed as a fraction of the mean quantization error. This means that all units must represent their respective subsets of data an a MQE smaller than a fraction of the 0 layer mean quantization error. For all units not satisfying this criteria, more representation is required for that area of the feature space and additional units are added. After a particular number of training iterations, the quantization errors are computed and the unit with the highest error is selected as the *error unit*. The most dissimilar neighbor of the error unit is chosen is and a row/ column of nodes is injected between them. The growth process continues until a second stopping criteria is met. Any units still not satisfying the global criteria are deemed to need extra representation. Child map are initialized below these units and trained with the subset of data mapped to its parent node.

In conclusion, the GHSOM is a growing self-organizing map architecture which has the ability to grow itself until the feature space is adequately represented. For areas of the space needing a more specific level of granularity, a hierarchical structure is imposed to "fill-in" areas of high density.

The GHSOM has been applied to the areas of finance, computer network traffic analysis, manufacturing and image analysis (Palomo 2017).

Chiang and Gader (1997) - *Hybrid fuzzy-neural systems in handwritten word recognition*

Summary:

Frigui and Gader (2009) - *Detection and Discrimination of Land Mines in Ground-Penetrating Radar Based on Edge Histogram Descriptors and a Possibilistic K-Nearest Neighbor Classifier*

Summary:

Fritzke (1994) - *A Growing Neural Gas Network Learns Topologies*

Summary: Abstract: An incremental network model is introduced which is able to learn the important topological relations in a given set of input vectors by means of a simple Hebb-like learning rule. In contrast to previous approaches like the "neural gas" method of Martinetz and Schulten (1991, 1994), this model has no parameters which change over time and is able to continue learning, adding units and connections, until a performance criterion has been met. Applications of the model include vector quantization, clustering, and interpolation.

In contrast to SOMs and "growing cell structures", which can project data onto non-linear subspaces which are chosen *a priori*, the GNG is able to adapt its topology to match that of the input data distribution. The growing process continues until a pre-defined level of quantization error has been reached.

The base algorithm is outlined in Palomo (2017), *Growing Hierarchical Neural Gas Self-Organizing Network*.

Palomo and Lopez-Rubio (2017) - *The Growing Hierarchical Neural Gas Self-Organizing Neural Network*

*Summary:*Abstract: The growing neural gas (GNG) self-organizing neural network stands as one of the most successful examples of unsupervised learning of a graph of processing units. Despite its success, little attention has been devoted to its extension to a hierarchical model, unlike other models such as the self-organizing map, which has many hierarchical versions. Here, a hierarchical GNG is presented, which is designed to learn a tree of graphs. Moreover, the original GNG algorithm is improved by a distinction between a growth phase where more units are added until no significant improvement in the quantization error is obtained, and a convergence phase where no unit creation is allowed. This means that a principled mechanism is established to control the growth of the structure. Experiments are reported, which demonstrate the self-organization and hierarchy learning abilities of our approach and its performance for vector quantization applications. Experiments were performed in structure learning, color quantization, and video sequence clustering.

The aim of this method was to improve the adaptation ability of the Growing Hierarchical Self-Organizing Map proposed by Rauber (2002). This was to be done through the extension of the Growing Neural Gas, which disposes of the fixed lattice topology enforced by the SOM. Addtionally, the GNG learns a dynamic graph with variable numbers of neurons and connections. The graph represents the input data in a more plastic and flexible way than the fixed-topology map.

All clustering methods that learn a hierarchical structure have advantages even when used for non-hierarchical data. The learned hierarchical structure can be pruned at several levels, which yields alternative representations of the input data set at different levels of detail. This can be used to visualize a data set in coarser or more detailed way. For vector quantization applications, the different pruning levels correspond to smaller or larger codebooks, so that a balance can be attained between the size of the codebook and the quantization error within the same hierarchical structure.

The growing hierarchical neural gas (GHNG) model is defined as a tree of self-organizing graphs. Each graph is made of a variable number of neurons or processing units, so that its size can grow or shrink during learning. In addition, each graph is the child of a unit in the upper level, except for the top level (root) graph. The training procedure is described by the following:

Each graph begins with $H \geq 2$ units and one or more undirected connections between them. Both the units and connections can be created and destroyed during the learning process. It is also not necessary that the graph is connected. Let the training set be denoted as $\mathcal{S}$ with $\mathcal{S} \subset \mathbb{R}^D$, where D is the dimensionality of the input space. Each unit $i \in \{1, \ldots, H\}$ has an associated prototype $\boldsymbol{w}_i \in \mathbb{R}^D$ and an error variable $e_i \in \mathbb{R}$, $e_i \geq 0$. Each connection has an associated age, which is a nonnegative integer. The set of connections will be notetd as $A \subseteq \{1, \ldots, H\} \times \{1, \ldots, H\}$. The learning mechanism for the GHNG is based on the original GNG, but includes a novel procedure to control the growth of the graph. First, a growth phase is performed where the graph is allowed to enlarge until a condition is met, which indicates that further growing would provide no significant improvement in the quantization error. After that, a convergence phase is executed where no unit creation is allowed in order to carry out a fine tuning of the graph. the leraning algorithm is provided in the following steps.

I believe the author's experimental approach did not take advantage of the method's strengths. The author's only demonstrated experiments in vector quantization, and used corresponding metrics. This method could be used to represent manifold topology of differing dimensionality. This could be useful in HSI imagery, for example where different environment patches require manifold representations of various dimensionality. Additionally, this could potentially be used to handle the sensor fusion problem with sensor loss/ drop-out.

Sun et al. (2017) - *Online growing neural gas for anomaly detection in changing surveillance scenes*
Summary:

Lopez-Rubio and Palomo (2011) - *Growing Hierarchical Probabilistic Self-Organizing Graphs*
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Palomo and Lopez-Rubio (2016) - *Learning Topologies with the Growing Neural Forest*
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1.3 Deep Learning

Goodfellow et al. (2016) - *Deep Learning*
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Haykin (2009) - *Neural networks and learning machines*
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Dai et al. (2017) - *dden Talents of the Variational Autoencoder*
Summary:

Rojas (1996) - *Associative Networks*
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2 Information Measures

Arandjelovic et al. (2005) - *Face recognition with image sets using manifold density divergence*
Summary:

Wang et al. (2012) - *ManifoldManifold Distance and its Application to Face Recognition With Image Sets*
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3 Manifold Regularization

Tsang and Kwok (2007) - *Large-Scale Sparsified Manifold Regularization*
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Ren et al. (2017) - *Unsupervised Classification of Polarimetirc SAR Image Via Improved Manifold Regularized Low-Rank Representation With Multiple Features*
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Belkin et al. (2006) - *Manifold Regularization: A Geometric Framework for Learning from Labeled and Unlabeled Examples*
Summary:

Ratle et al. (2010) - *Semisupervised Neural Networks for Efficient Hyperspectral Image Classification*
Summary:

Li et al. (2015) - *Approximate Policy Iteration with Unsupervised Feature Learning based on Manifold Regularization*
Summary:

Meng and Zhan (2018) - *Zero-Shot Learning via Low-Rank-Representation Based Manifold Regularization*
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4 Multiple Instance Learning

4.1 Multiple Instance Concept Learning

Bocinsky (2019) - *Learning Multiple Target Concepts from Uncertain, Ambiguous Data Using the Adaptive Cosine Estimator and Spectral Match Filter*
Summary:

Jiao (2017) - *Target Concept Learning From Ambiguously Labeled Data*
Summary:

McCurley et al. (2019) - *Comparison of hand-held WEMI target detection algorithms*
Summary:

Bocinsky et al. (2019) - *Investigation of initialization strategies for the Multiple Instance Adaptive Cosine Estimator*
Summary:

Zare et al. (2015) - *Multiple instance dictionary learning for subsurface object detection using handheld EMI*
Summary:

Cook (2015) - *Task driven extended functions of multiple instances (TD-eFUMI)*
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Cook et al. (2016) - *Buried object detection using handheld WEMI with task-driven extended functions of multiple instances*
Summary:

Zare et al. (2016) - *Multiple Instance Hyperspectral Target Characterization*
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Jiao and Zare (2017) - *Multiple instance hybrid estimator for learning target signatures*
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Xiao et al. (2017) - *A Sphere-Description-Based Approach for Multiple-Instance Learning*
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Cheplygina et al. (2019) - *Not-so-supervised: A survey of semi-supervised, multi-instance, and transfer learning in medical image analysis*
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Li et al. (2017) - *Cross-validated smooth multi-instance learning*
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Cheplygina et al. (2016) - *Dissimilarity-Based Ensembles for Multiple Instance Learning*
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Wang et al. (2017) - *Incorporating Diversity and Informativeness in Multiple-Instance Active Learning*
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Hajimirsadeghi and Mori (2017) - *Multi-Instance Classification by Max-Margin Training of Cardinality-Based Markov Networks*
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Du et al. (2016) - *Multiple Instance Choquet integral for classifier fusion*
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Ilse et al. (2018) - *Attention-based Deep Multiple Instance Learning*
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Karem and Frigui (2016) - *Multiple Instance Learning with multiple positive and negative target concepts*
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Xiao et al. (2017) - *Multiple-Instance Ordinal Regression*
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Gao et al. (2017) - *C-WSL: Count-guided Weakly Supervised Localization*
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Li et al. (2017) - *Multi-View Multi-Instance Learning Based on Joint Sparse Representation and Multi-View Dictionary Learning*
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Cao et al. (2016) - *Weakly Supervised Vehicle Detection in Satellite Images via Multi-Instance Discriminative Learning*
Summary:

Dietterich et al. (1997) - *Solving the multiple instance problem with axis-parallel rectangles*
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Maron and Lozano-Pérez (1998) - *A Framework for Multiple-instance Learning*
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Maron and Ratan (1998) - *Multiple-Instance Learning for Natural Scene Classification*
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Carbonneau et al. (2016) - *Multiple Instance Learning: A Survey of Problem Characteristics and Applications*
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Zhang and Goldman (2002) - *EM-DD: An Improved Multiple-Instance Learning Technique*
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Zare and Jiao (2014) - *Extended Functions of Multiple Instances for target characterization*
Summary:

Jiao et al. (2018) - *Multiple instance hybrid estimator for hyperspectral target characterization and subpixel target detection*
Summary:

4.2 Multiple Instance Classification

Cao et al. (2016) - *Weakly Supervised Vehicle Detection in Satellite Images via Multi-Instance Discriminative Learning*
Summary:

4.3 Multiple Instance Regression

Trabelsi and Frigui (2018) - *Fuzzy and Possibilistic Clustering for Multiple Instance Linear Regression*
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Ruiz et al. (2018) - *Multi-Instance Dynamic Ordinal Random Fields for Weakly Supervised Facial Behavior Analysis*
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5 Fusion

5.1 Classical Approaches

5.1.1 General Approach

Mohandes et al. (2018) - *Classifiers Combination Techniques: A Comprehensive Review*
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Ruta and Gabrys (2000) - *An Overview of Classifier Fusion Methods*
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Tulyakov et al. (2008) - *Review of Classifier Combination Methods*
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Hackett and Shah (1990) - *Multi-sensor fusion: a perspective*
Summary:

Zhang (2010) - *Multi-source remote sensing data fusion: Status and trends*
Summary:

5.1.2 Hierarchical Mixture of Experts

Jordan and Jacobs (1993) - *Hierarchical mixtures of experts and the EM algorithm*
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Yuksel et al. (2012) - *Twenty Years of Mixture of Experts*
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Beyer et al. (2009) - *Heterogeneous mixture-of-experts for fusion of locally valid knowledge-based submodels*
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Shazeer et al. (2017) - *Outrageously Large Neural Networks: The Sparsely-Gated Mixture-of-Experts Layer*
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5.1.3 Choquet Integral

Du (2017) - *Multiple Instance Choquet Integral For MultiResolution Sensor Fusion*
Summary:

Ryan E. Smith (2017) - *Aggregation of Choquet integrals in GPR and EMI for handheld platform-based explosive hazard detection*
Summary:

Smith et al. (2017) - *Genetic programming based Choquet integral for multi-source fusion*
Summary:

Du and Zare (2019) - *Multiple Instance Choquet Integral Classifier Fusion and Regression for Remote Sensing Applications*
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Anderson et al. (2017) - *Binary fuzzy measures and Choquet integration for multi-source fusion*
Summary:

Du and Zare (2018) - *Multi-Resolution Multi-Modal Sensor Fusion For Remote Sensing Data With Label Uncertainty*
Summary:

Gader et al. (2004) - *Multi-sensor and algorithm fusion with the Choquet integral: applications to landmine detection*
Summary:

5.1.4 Deep Learning

L.Jian et al. (2019) - *A Symmetric Encoder-Decoder with Residual Block for Infrared and Visible Image Fusion*
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Vivar et al. (2019) - *Multi-modal Graph Fusion for Inductive Disease Classification in Incomplete Datasets*
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Dawn et al. (2010) - *Remote Sensing Image Registration Techniques: A Survey*
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Brigot et al. (2016) - *Adaptation and Evaluation of an Optical Flow Method Applied to Coregistration of Forest Remote Sensing Images*
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Zitov and Flusser (2003) - *Image registration methods: a survey*
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Butenuth et al. (2007) - *Integration of heterogeneous geospatial data in a federated database*
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Guo (2019) - *Latent Variable Algorithms for Multimodal Learning and Sensor Fusion*
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Zhang et al. (2019) - *Fusion of Heterogeneous Earth Observation Data for the Classification of Local Climate Zones*

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Shen et al. (2016) - *An Integrated Framework for the SpatioTemporalSpectral Fusion of Remote Sensing Images*

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6 Outlier/ Adversarial Detection

7 Army

Hall et al. (2018) - *Probabilistic Object Detection: Definition and Evaluation*

*Summary:*A probabilistic object detection metric (PDQ - Probability-based Detection Quality) was proposed, thus defining the new task of defining probabilistic object detection metrics. The ability of deep CNNs to quantify both *epistemic* and *aleatoric uncertainty* is paramount for deployment safety-critical applications. PDQ aims to measure the accuracy of an image object detector in terms of its label uncertainty and spatial quality. This is achieved through two steps. First, a detector must reliably quantify its *semantic uncertainty* by providing full probability distributions over known classes for each detection. Next, the detectors must quantify spatial uncertainty by reporting *probabilistic bounding boxes*, where the box corners are modeled as normally distributed. A loss function was constructed to consider both label and spatial quality when providing a final detection measure. The primary benefit of this method is that it provides a measure for the level of uncertainty in a detection.

Is it possible to replace the probabilistic metric with a possibilistic one? Could this be more effective at handling outlying cases?

Mahalanobis and McIntosh (2019) - *A comparison of target detection algorithms using DSIAC ATR algorithm development data set*

*Summary:*The authors provided an initial characterization of detection performance on the DSIAC dataset using the *Faster R-CNN* algorithm and *Quadratic Correlation Filter (QCF)*. Performance was evaluated on two datasets, "easy" and "difficult", where the difficulty was determined by number of pixels on target and local contrast. Under difficult conditions, the Faster R-CNN algorithm achieved noteworthy performance, detecting as much as 80% of the targets at a low false alarm rate of 0.01 FA/Square degree. The dataset was limited by a lack of background diversity.

Tanner and Mahalanobis (2019) - *Fundamentals of Target Classification Using Deep Learning*

Summary: A shallow CNN was utilized for ATR on the DSIAC MWIR dataset. The goal of the study was to determine the range of optimal thresholds which would optimally separate the target and clutter class distributions defined by the CNN predictions (output of softmax), as well as determine an upper bound on the number of training images required for optimizing performance. The shallow CNN (5 layers) and a Difference of Gaussians (DoG), which finds regions of high intensity on dark backgrounds were used to detect and classify targets. The CNN could correctly classify 96% of targets as targets and as few as 4% of clutter as targets. It was found that the DoG detector failed when the targets were small (long range) or if the overall image was bright (infrared taken during the daytime). It was also determined that guessing the bright pixels were at the center of the targets was a bad assumption. (The brightest part of a target is not necessarily at its center.)

Li2 - *Collaborative sparse priors for multi-view ATR*
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Kokiopoulou and Frossard (2010) - *Graph-based classification of multiple observation sets*
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8 Segmentation

Caselles et al. (1997) - *Geodesic Active Contours*
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Álvarez et al. (2010) - *Morphological Snakes*
Summary: The authors introduce a morphological approach to curve evolution. Snakes or curves iteratively solve partial differential equations (PDEs). By doing so, the shape of the snake deforms to minimize the internal and external energies along its boundary. The internal component keeps the curve smooth, while the external component attaches the curve to image structures such as edges, lines, etc. Curve evolution is one of the most widely used image segmentation/ object tracking algorithms. The main contribution of the paper is a new morphological approach to the solution of the PDE associated with snake model evolution. They approach the solution using only inf-sup operators which has the main benefit of providing simpler level sets (0 outside the contours and 1 inside).

Márquez-Neila et al. (2014) - *A Morphological Approach to Curvature-Based Evolution of Curves and Surfaces*
Summary:

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