Automatic Modelling Image Represented Objects Using a Statistic Based Approach

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Abstract: With this work its intended to describe new methodologies to automatically extract significant points, from objects represented in imagens, useful to construct Point Distribution Models.

Index:

1. Introduction;
2. Point Distribution Model (PDM);
3. Active Shape Model (ASM) and Active Appearance Model (AAM);
4. Automatic extraction of objects landmarks;
5. Used models and experimental results;
6. Conclusions and Future Work.
Analysis of objects represented in images

– Area of Computational Vision
  • “Set of methods and techniques that make computational systems capable of interpreting images.”

– Object modelling
  • Flexible models – statistical models developed to deal with problems which the images contained objects of variable shapes.

– Applications (for example)
  • Medicine – locating bones and organs in medical images;
  • Industry – industrial inspection;
  • Security systems – face recognition;
  • …
• Point Distribution Models:
  – Proposed by Cootes and Taylor in 1992;
  – Method for object modelling based on statistical analysis;
  – (Goal) To obtain the mean shape of the object in study as well as its main modes of variation;
  – Can be used to construct:
    • Active Shape Models;
    • Active Appearance Models.
  – Can be used for image analysis, like image segmentation.
Steps:

- **Construction of the vector that contains the landmarks co-ordinates:**
  \[
  x_i = (x_{i1}, \ldots, x_{in}, y_{i1}, \ldots, y_{in})^T \\
  i = 1 \ldots N_s, \quad N_s \text{ number of objects,} \\
  n \text{ number of landmarks.}
  \]

- **Object representation by a set of labelled landmark points.**

- **Find the mean shape, }\bar{\pi} and the variation modes:**
  - apply a Principal Component Analysis to the co-ordinates of the landmarks.

- **Alignment of all objects from the training set by their rotation, translation and scale.**

- **Modelo Pontual de Distribuição:**
  \[
  x = \bar{x} + Pb \\
  - P = (p_1 \ldots p_t) \text{ matrix with the first } t \text{ eigen vectors;} \\
  - b = (b_1 \ldots b_t) \text{ vector of weights for each mode.}
  \]
Using PDMs in object search (segmentation):

1. **Active Shape Models – ASMs:**
   - **Shape Model;**
   - **Intensity profiles of each landmark:**
     - The local grey-level environment about each landmark are similar.
   - **Search stage:**
     - At each point is calculated a suggested movement required to displace the point to a better position;
     - The changes in the overall position, orientation and scale are calculated;
     - Parameters actualization considering the shape limits.
2. **Active Appearance Models – AAMs:**
   - Shape model;
   - Texture model:
     - Deform each example image so that its control points match the mean shape;
     - Sample the grey level information from the shape-normalized image over the region covered by the mean shape:
       \[ g = \bar{g} + P_g b_g. \]
   - Appearance model:
     - Combination of the shape model (geometric) with the texture model (intensity).
   - Active model:
     - Starts to learn the relationship between model parameter displacements and the residual errors, induced between a new image and a synthesised model build during a training stage; AAM measure the current residuals and use the model to predict changes to the current parameters.
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- Automatic extraction of landmarks (object - hand)

1. Segmentation of the training image to extract the hand contour, using an algorithm to detect skin regions;
2. Find contour zones with high curvature;
3. Find the contour corresponding to the hand (delete pulse and arm contours);
4. Choose the number of landmarks to consider on high curvature zones and in between them.
• **Face contour extraction**

1. Extraction of face contour using an algorithm to detect skin regions;
2. Eyes and eyebrows localization using an appropriate chromatic map;
3. Mouth identification through the saturation values of the image;
4. Extraction of the landmarks from the contours identified.
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• Face regular mesh

1. Face and eyes localization like described in the previous method;
2. Adjust a regular rectangular mesh to the face region, rotated according the angle given by eye centroids;
3. Consider the nodes of the mesh as landmarks;
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• Face adaptative multi-resolution mesh

  1. Face, eyes and mouth localization like described in the first method;
  2. Adjust of a rectangular mesh formed by two smaller adaptative meshes: one for the eyes regions and another for the mouth;
  3. Add additional nodes in the outer mesh;
  4. Consider the nodes of the meshes as landmarks.

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Built models:

1. Hand
   - 25 training images;
   - 4 different persons;
   - Automatically labelled with 65 landmarks.

2. Face
   - 22 training images;
   - 1 person;
   - Automatically labelled with 44, 36 or 54 landmarks.
1. Hand

- **ASM**
  - The first 6 modes of variation can explain 95% of the shape variance.
2. Face contour extraction

- **Shape model**
  - The first 13 modes explain 95% of the shape variance.

- **Appearance model**
  - The first 12 modes of variation can explain 95% of the observed variance.
2. Face – regular and adaptative meshes

- **Appearance model II**
  - The first 5 modes explain 95% of the appearance variance.

- **Appearance model III**
  - The first 8 modes explain 95% of the observed variance.
3. Active Shape Models

(“new” images)

Initial position  9th iteration  19th iteration  29th iteration
error: 4.25±3.17

Initial position  8th iteration  14th iteration  18th iteration
error: 6.20±5.26
3. **Active Appearance Models**

**Method I**
- Original image
- 7th iteration
- 17th iteration
- 21st iteration
- Error: $5.11 \pm 4.15$

**Method II**
- Original image
- 10th iteration
- 19th iteration
- 24th iteration
- Error: $2.93 \pm 0.11$

**Method III**
- Original image
- 10th iteration
- 20th iteration
- 23rd iteration
- Error: $1.58 \pm 0.43$

 (*“new” image*)
Conclusions:

• A methodology to build flexible models was presented, using a statistical approach, for deformable objects represented in images.

• The models used have applications in different areas, since locating bones in medical images to face recognition.

• Experimental results show that active models can be used to segment hands and faces in new images.

• The methodologies developed to automatically extract landmarks of objects represented in images of type hands and faces obtained very interesting results.
Future work:

- Obtain more experimental results using the methodologies developed;
- Compare the use of active shape models with the active appearance models in different applications.
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