Available online at www.elixirpublishers.com (Elixir International Journal)

Electrical Engineering

Elixir Elec. Engg. 70 (2014) 24076-24079

ISSN: 2229-712X

A Review of Image Morphing Techniques

Anant M.Bagade[1,*] and S.N.Talbar[2]

[1]Department of Information Technology, Pune Institute of Computer Technology, Pune, Maharashtra, India.

[2]Department of Electronics and Telecommunication, SGGS Institute of Engineering and Technology, Nanded, Maharashtra, India.

ARTICLE INFO

Article history:

Received: 26 November 2013;
Received in revised form:
25 April 2014;
Accepted: 6 May 2014;

Keywords

Image morphing,
Coordinate transformation,
Interpolation,
Morphing Techniques.

ABSTRACT

Image morphing is a very important tool in film and animation industry. There is a potential need to do the research in the field of image morphing. There are lots of applications based on morphing in the area of image processing and image data security. There has been a significant improvement in the research related to image morphing in the past few years. In this paper, state of the art methods from 1980, s of morphing is discussed. In various sections of the paper methods related to transformation of pixels, interpolation and other methods of image morphing are discussed. A sincere attempt is made to address the comparison of these methods depending upon various parameters and techniques. This will help the researcher to compare and identify the method for further research. It is also highlighted the possible direction of research till date. Moreover the paper also contains a comprehensive bibliography of many selected papers appeared in reputed journals and conference proceedings as an aid for the researchers working in the field of image morphing. It includes old research papers to new research papers till date.

Introduction

Morphing is defined as an animated transformation from one image to another image. Morphing involves image processing techniques like warping [36], cross dissolving, transformations, interpolations. Cross dissolving allow to fade one image to another image using linear interpolation. This technique is visually poor because the features of both images are not aligned, and that will result in double effect. In order to overcome this problem, warping is used to align the two images before cross dissolving. Warping determines the way pixels from one image are correlated with corresponding pixels from the other image [43]. It is needed to map the important pixels, else warping doesn't work. Filmmakers from Hollywood use advanced morphing techniques to generate special effects. Even Disney animations are made using morphing, for speeding production. Because there are a small number of applications to generate face morphing, there is an increased interest in this domain. This field of morphing has a tremendous scope in the applicators like animation, image data security [54]. Image morphing has been the subject of much attention in recent years. It has proven to be a powerful visual effects tool in film and television. There are many breathtaking examples in film and television depicting the fluid transformation of one digital image into another [17]. Image metamorphosis between two images begins with an animator establishing their correspondence with pairs of feature primitives, e.g., mesh nodes, line segments, curves, or points [39]. Feature specification is the most tedious aspect of morphing [1].The sequence of images should form a natural-or reasonable-looking transition from the first image to the second. This problem is ill posed because of a priori information about the images or the scene that they depict. [2].

3D geometry morphing techniques have been developed for polygonal meshes [3] [4] [5] and volumetric representations [6] [7] and they allow for additional effects such as changes in viewpoint. Many real objects have geometry and surface [51] [53] properties that are too difficult to model or recover by traditional graphics and computer vision techniques. Light fields are often used to model the appearance of such objects from multiple viewpoints and a method for morphing based on the light field representation has recently been proposed [8]. With user specification of 3D polygon features in the light fields, this approach effectively combines the advanced morphing effects of 3D geometry morphing [52] with the fine appearance details of ages. Takaslii Kanai [9] compares the issues in 3D metamorphosis to establish surface correspondence between the source and target objects. By which each point on the surface of the source object maps to a point on target surface .To improve the quality of 3D morphing between two triangular meshes [50], particularly considering the issue like the metamorphosis of arbitrary meshes. In general, the two meshes have different topological structures, that is, vertex/edge/face graph structures [9]. Seungyong Lee et al. [10] describes another method of morphing called layered Morphing. It consists of two kinds of processes. One is a process to separate a base image into layered images and the other is to perform the morphing of images layer by layer. The first process is to separate a base image into layered images. Suppose there is a base image in which one object is in front of another object keeping a part of it out of sight. In this case, if you perform morphing without separating it into layers, the resulting image cannot present observers a partially hidden by another object even when they change their position [10]. Sederlmg et al. [11] Presented an improved interpolation method, in which interpolated entities are edge lengths and angles between edges rather than vertex locations. An optimization algorithm is performed, solely for the purpose of ensuring that the intermediate polygons define closed shapes. This method handles many situations successfully, including cases where the shapes are affine transformations of each other or where parts of the shapes are transformed affinely [11]. Steven et al. [12] describe the effect of 2D and 3D morphing. Recently there has been a great deal of interest in morphing techniques for producing smooth transitions between images.

Tele:
E-mail addresses: anantbagade@gmail.com

These techniques combine 2D interpolations of shape and colour to create dramatic special effects.

The remaining paper is organized into four sections. Section II discusses the different morphing techniques depending on the pixel transformation. Section III discusses the morphing techniques depending upon the interpolation. Section IV discusses the other morphing techniques. Section V reports the observation and comparison. The paper is concluded in the last section. A comprehensive bibliography of more than 50 references is provided for the user for further research. The references include the most relevant papers recently published as well as some older papers, which can give a comprehensive outline of the developments in the field of research.

Transformation methods

The work on image transformation started in early 1980s. Mesh warping was pioneered at Industrial Light & Magic ILM) by Douglas Smythe for use in the movie *Willow* in 1988[13] [14]. It has been successfully used in many subsequent motion pictures [48]. T. Beier and S. Neely [15] developed a model for pixel transformation using field morphing. It transforms the pixels corresponding to the lines drawn on source and destination image. Thin plate Spline is another technique of image morphing [19]. It transforms the pixels corresponding to the surface positions. Affine, linear and bilinear transforms are used to generate the morphs [19]. The following section discusses the mesh morphing, field morphing, thin plate Spline and coordinate transformation techniques.

Mesh Morphing

A mesh M is described by the connectivity k of its vertices, edges, and faces and geometric positions *V* of the number of vertices. The geometric realization $\varphi\ V$ of the mesh maps $\{V, k\}$ be the set of all points comprising the mesh and, thus, describes the shape of the object represented [45]. Aaron W. F. Lee describes the techniques for multi resolution mesh morphing [46] [44].G.Wolberg [14] illustrate the 2-pass mesh warping algorithm. There are two images in the morphing process; one is a source and destination image. Consider the image sequence shown in Figure 1. The middle image represents a metamorphosis (or morph) between the two faces at both ends of the row. G.Wolberg[14] describes the algorithm for mesh morphing. It consider the two meshes M_s (source) and M_t(target).These two meshes are linearly interpolate the mesh M.I_s and I_t are source and target images respectively. The use of meshes for feature specification facilitates a straightforward solution for warp generation: bicubic spline interpolation [14]. Fant's algorithm was used to resample the image in a separable implementation [13, 14].The advantage of this technique is that controls are given to the animator [49]. The disadvantage, if the grid size increases the computations also increases. Figure 1 shows the example of mesh morphing.

Figure 1.Mesh Morphing

Field Morphing

Beer and Neely [15] proposed a technique for morphing based upon fields of influence surrounding two-dimensional control primitives. This approach is called field morphing. It is based on the pixel distance with respect to the lines drawn on source and destination image. There are two ways to warp an image. The first, called forward mapping, scans through the source image pixel by pixel, and copies them to the appropriate place in the destination image. The second, reverse mapping, goes through the destination image pixel by pixel, and samples the correct pixel from the source image. The most important feature of inverse mapping is that every pixel in the destination image gets set to something appropriate. In the forward mapping case, some pixels in the destination might not get painted, and would have to be interpolated. The author also proposes the transformation techniques with one pair of lines and two pair of lines. We can mark only one feature on source and destination image using single line and using multiple lines we can mark many features on both the images to increase in efficiency.Vector calculus is used to find the distanace of the pixels from the lines and pixel transformation to destination image.This is a superior technique but the disadvantage is all the controls are given to the animator.The future scope of this technique is automatic feature selction for morphing.

C. Thin Plate Spline Based Image Morphing

` Fred L. Bookstelin has invented the method of Thin-plate Spline [47] in the year 1989.The author proved that this is a conventional tool for surface interpolation over scattered data. It is an interpolation method that finds a minimally bended smooth surface that passes through all given points. The name Thin Plate comes from the fact that a Thin-plate Spline more or less simulates how a thin metal plate would behave if it was forced through the same control points. Let us denote the target function values V_i at locations (X_i,Y_i) in the plane, with i=1,2,…….p where p is the number of feature points. In particular, we will set V_i equal to the coordinates (X_i,Y_i) in turn to obtain one continuous transformation for each coordinate. An assumption is made that the locations (X_i,Y_i) are all different and are not collinear.

Figure 2 is a simple example of coordinate transformation using Thin-plate Spline. It starts from two sets of points for which it is assumed that the correspondences are known (a). The Thin-plate Spline warping allows an alignment of the points and the bending of the grid shows the deformation needed to bring the two sets on top of each other (b) [24]. In case of Thin-plate Spline applied to coordinate transformation we actually use two splines, one for the displacement in the x direction and one for the displacement in the y direction. The two resulting transformations are combined into a single mapping [19].The morph depends upon the stretching of the Thin plate.

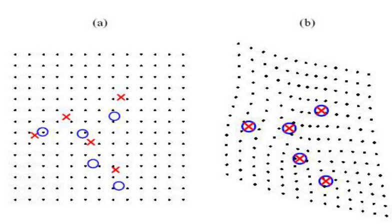

Figure 2: Coordinate Transformation using Thin-plate Spline

Coordinate Transformation Morphing

There are many coordinate transformations for the mapping between two triangles or between two quadrangles. It is usually used affine and bilinear transformations for the triangles and quadrangles, respectively. Besides, bilinear interpolation is performed in pixel sense.

Affine Transformation

Suppose there are two triangles ABC and DEF. An affine transformation is a linear mapping from one triangle to another. For every pixel p within triangle ABC, assume the position of p is a linear combination of A, B, and C vectors. The transformation is given by the following equations

$$p = \lambda_1 A + \lambda_2 B + \lambda_3 C$$

$$\lambda_1 + \lambda_2 + \lambda_3 = 1 \quad \lambda_i \geq 0$$

$$q = T(p) = \lambda_1 D + \lambda_2 E + \lambda_3 F$$

Here, □1and □2, are unknown and there are two equations for each of the two dimensions. Consequently, □ 1 and □2 can be solved, and they are used to obtain q. The affine transformation is a one-to-one mapping between two triangles [19].

Bilinear Transformation

Suppose there are two quadrangles ABCD and EFGH, according to Figure 3.

The bilinear transformation is a mapping from one quadrangle to another. For every pixel p within quadrangle ABCD, it is assumed that the position of p is linear combination of vectors A, B, C, and D. Bilinear transformation is given by the following equations:

$$p = (1-u)(1-v)A + u(1-v)B + uvC + (1-u)vD \quad 0 \leq u, v \leq 1$$

$$q = (1-u)(1-v)E + u(1-v)F + uvG + (1-u)vH$$

` There are two unknown components: u and v. Because this is a 2D problem, we have 2 equations. So, u and v can be solved, and they are used to obtain q. Again, the bilinear transformation is a one-to-one mapping for two quadrangles [19].

Cross Dissolving

After coordinate transformations for each of the two facial images are performed, the feature points of these images are matched. i.e., the left eye in one image will be at the same position as the left eye in the other image. To complete face morphing, we need to do cross-dissolving as the coordinate transforms are taking place. Cross dissolving is described by the following equation,

$$C(x,y) = \alpha A(x,y) + (1-\alpha)B(x,y) \quad 0 \leq \alpha \leq 1$$

Where A, B are the pair of images, and C is the morphing result. This operation is performed pixel by pixel, and each of the color components RGB is dealt with individually [19]. Table 1 compares the stated methods with different parameters. This comparision will help the researcher to classify and choose the appropriate method.

REFERENCES

[1] George Wolberg, "Recent Advances in Image Morphing", Proc. Computer Graphics Intl. '96, Pohang, Korea,pp.1-8, June 1996.

[2] Ross T.Whitaker, Member, IEEE,"A level-set approach to image blending", IEEE Transactions on Image Processing,vol.9,No.11,pp. 1849 - 1861 ,2000.

[3] S.-Y. Lee, K.-Y. Chwa, J. Hahn, and S. Y. Shin,"Image morphing using deformable surfaces",Proc.Computer Animation '94, pp.31–39, 1994.

[4] S.-Y. Lee, K.-Y. Chwa, J. Hahn, and S. Y. Shin,"Image morphing using deformation techniques", J. Visualization and Computer Animation, 7(1), pp.3–23, 1996.

[5] S.-Y. Lee, K.-Y. Chwa, S. Y. Shin, and G. Wolberg,"Image metamorphosis using snakes and free-form deformations", Computer Graphics (Proc. SIGGRAPH '95), pp.439–448, 1995.

[6] P. Litwinowicz and L. Williams,"Animating images with drawings", Computer Graphics (Proc. SIGGRAPH '94), PP. 409–412, 1994.

[7]D. Cohen-Or, A. Solomovici, and D. Levin, "Three-Dimensional Distance Field Metamorphosis, "ACM Trans. Graphics, vol. 17, no. 2, pp. 116-141, Apr. 1998."

[8] Z. Zhang, L. Wang, B. Guo, and H.-Y. Shum, "Feature-Based Light Field Morphing," ACM Trans. Graphics (Proc. ACM SIGGRAPH 2002), vol. 17, no. 2, pp. 116-141, July 2002.

[9] Takaslii Kanai et al.," Metamorphosis of Arbitrary Triangular Meshes",Compuer graphics and applications,IEEE , vol.20 ,issue:2,pp.62-75,2000.

[10] Seungyong Lee et al.," Image Metamorphosis with Scattered Feature Constraints", IEEE Transactions on visualization and computer graphics,vol.2,no.4,pp.337-354, December 1996.

Table 1: Comparison

Sr. No.	Method	Parameters		
		Feature selection	Pixel transformation w.r.t. line	Coordinate transformation
A	Mesh Morphing	√	X	X
B	Field Morphing	√	√	X
C	Thin Plate SPline based Morphing	X	X	√
D	Coordinate Transformation morphing	X	X	√

Table 2: Comparison

Sr. No.	Method	Parameters			
		Correspondence of vertices	**Fuzzy interpolation**	**Movement of contour**	**Pixel transformation**
A	Morphing using fuzzy vertex interpolation	√	√	X	X
B	A level set approach for morphing	X	X	√	X
C	View morphing	X	X	X	√

Table 3: Comparison

Sr. No.	Method	Parameters		
		Image separation	**Polygon and feature line**	**Object transformation**
A	Layered morphing	√	X	X
B	Star skeleton approach for morphing	X	√	X
C	Volumetric morphing	X	X	√
D	A light field morphing	X	√	X

[11] Michal Shapira and Ari Rappoport, "Shape blending using the star skeleton representation", IEEE, vol.15,issue:2,pp.44-50,March 1995.
[12] Steven M. Seitz Charles R. Dyer," View Morphing",SIGGRAPH96,pp.21-30,1996.
[13] K. M. Fant. A nonaliasing, "real-time spatial transform technique". IEEE Computer Graphics and Applications, 6(1),pp.71– 80, January 1986.
[14] G.Wolberg, "Digital Image Warping", IEEE Computer Society Press, Los Alamitos, CA, pp.64-71,1990.
[15] T. Beier and S. Neely, "Feature-based image metamorphosis", Computer Graphics (Proc. SIGGRAPH '92), 26(2), pp.35–42, 1992.
[16] Endo et al.," Image-based walk-through system for large-scale scenes", Proc.VSMM'98, pp. 269-274,1998.
[17] Hirose, M., Tanikawa, T. & Endo, T.,"Building a virtual world from the real world", Proc. ISMR'99, pp. 183-197,1999.
[18] Takaaki Endo1et al.,"Cybercity Walker-Layered Morphing Method",Mixed Reality Systems Laboratory Inc. 6-145 Hanasakicho, Nishi-ku,Yokohama 220-0022 Japan.
[19] Alexandru Vlad,"Image Morphing Techniques",Volume 5,Issue 1,JIDEG,pp.25-28,2010.
[20] Mochal Shapira and Rappoport,"Shape Blending Using the Star-Skeleton Representation" ,IEEE, Computer Graphics, vol.15, issue: 2,pp.44-50,1995.
[21] T.W. Isederberg, "A Physically Based Approach to 2D Shape Blending," Computer Graphics (Proc. Siggraph), Vol. 26,No. 2, pp. 25-34,1992.
[22] T.W. Sederberg et al.,"2D Shape Blending: An Intrinsic Solution to the Vertex Path Problem," Computer Graphics (Proc. Siggraph), 1993, ACM, NewYork, pp. 15-18, 1993.
[23] K. Shoemake and T. Duff, "Matrix Animation and Polar Decomposition," Graphics Interface 92, Canadian Information Processing Soc., Toronto, Ontario, Canada,pp.258-264, 1992.
[24]H.Bremermann, "Pattern Recognition by Deformable Prototypes," in Structural Stability, the Theory of Catastrophes and Applications in the Sciences, Springer Notes in Mathematics, Springer-Verlag, Berlin and New York, Vol. 25, pp. 15-57,1976.
[25] J.F.Hughes, "Scheduled Fourier volume Morphing "Proc. Siggraph 92,ACM Press,New York,pp.43-46,1992.
[26] K.K.Cheung,K.Yu, and K.Kui, "Volume Invariant Metamorphosis for solid and Hollow Rolled Shape,"Proc.Shape Modeling Int'l,IEEE Computer Society Press,Los Alamitos,Calif.,pp.226-232,1997.
[27] T.Hc,S.Wang,and A.Kaufman,"Wavelet-Based Volume Morphing ."Proc.IEEE Visualization 94,IEEE Computer Society Press,Los Alamotos,Calif.,pp.85-92,1994.
[28] T.Hc,S.Wang, and A.Kaufman, "Wavelet-Based Volume Morphing ."Proc.IEEE Visualization 94,IEEE Computer Society Press, Los Alamotos,Calif.,pp.85-92, 1994.
[29] Yuefeng Zhang et al.,"A Fuzzy approach to digital image warping", Computer Graphics and Application, IEEE,vol. 16,issue:4,pp.34-41, 1996.
[30] Takashi Kanai,"Metamorphosis of arbitrary triangular meshes",Computer Graphics and Application, IEEE,pp.62-75 2000.
[31] S.Palmer,"Vision Science—Photons to Phenomenology". Cambridge, MA: MIT Press, pp.171-185,1999.
[32] RossT.Whitaker ,"A level-set approach to image blending",IEEE Transactions on Image Processing,Vol.9, N0.11,pp.1849-1861,2000.
[33] Z. Zhang, L. Wang, B. Guo, and H.-Y. Shum, "Feature-Based Light Field Morphing," ACM Trans. Graphics (Proc. ACM SIGGRAPH 2002), vol. 17, no. 2, pp. 116-141, July 2002.
[34] Z. Zhang, L. Wang, B. Guo, and H.-Y. Shum, "Feature-Based Light Field Morphing," ACM Trans. Graphics (Proc. ACM SIGGRAPH 2002), vol. 17, no. 2, pp. 116-141, July 2002.
[35] S.J. Gortler, R. Grzeszczuk, R. Szeliski, and M.F. Cohen, "The Lumigraph," Proc. SIGGRAPH '96, pp. 43-54, Aug. 1996.
[36] J. Gomes, B. Costa, L. Darsa, and L. Velho,"Warping and Morphing of Graphics Objects", Morgan Kaufmann, 1998.
[37] S.M. Seitz and C. R. Dyer, "View Morphing: Synthesizing 3D Metamorphoses Using Image Transforms," Proc. SIGGRAPH '96,pp. 21-30, Aug. 1996.
[38]M. Levoy and P. Hanrahan, "Light Field Rendering," Proc. SIGGRAPH '96, pp. 31-42, Aug. 1996.
[39]S.J. Gortler, R. Grzeszczuk, R. Szeliski, and M.F. Cohen, "The Lumigraph," Proc. SIGGRAPH '96, pp. 43-54, Aug. 1996.
[40]H.-Y. Shum and L.-W. He, "Rendering with Concentric Mosaics," Proc. SIGGRAPH '99, pp. 299-306, Aug. 1999.
[41]Lifeng, Stephen Lin,"Light Field Morphing Using 2D Features",IEEE Transaction of Visualization and Computer Geaphics,Vol.11,No.1,2005.
[42]Chen,S. E.,Andwilliams,L.,"View interpolation for image synthesis". Proc. SIGGRAPH 93. In Computer Graphics(1993), pp. 279–288,1993.
[43]N. Arad, N. Dyn, D. Reisfeld, and Y. Yeshurun.,"Image warping by radial basis functions: Applications to facial expressions", CVGIP: Graphical Models and Image Processing, 56(2),pp.161–172, March 1994.
[44] Marc Alexa, "Differential coordinates for local mesh morphing and deformation", The Visual Computer (2003) Springer-Verlag 2003 pp:105–114,2003.
[45] AaronW. F. Lee et al., "Multiresolution Mesh Morphing", Proceedings of the 26th annual conference on Computer graphics and interactive techniques SIGGRAPH 99 (1999), vol.99,pp.343-350,1999.
[46]Fred L. Bookstein," Principal Warps: Thin-Plate Splines and the Decomposition of Deformations", IEEE Transactions on pattern analysis and machine intelligence,vol.II,No. 6, pp.567-585,JUNE 1989.
[47]Won-Sook Lee,Nadia Magneat Thalmann,"Head Modeling from Pictures and Morphing in 3D with Image Metamorphosis Based on Triangulation Modeling and Motion Capture Techniques for Virtual Environments",Lecture Notes in Computer Science, Volume 1537/1998, pp.254-2671998.
[48]Seungong Lee et al., "Image metamorphosis with scattered feature constraints", IEEE transactions on visualization and computer graphics,vol.2,No.4,pp.337-354,December 1996.
[49]Marc Alexa," Differential coordinates for local mesh morphing and deformation", The Visual Computer,vol.19,No.2-3,pp.105-114,2003.
[50]Arthur Gregory et al.," Interactive surface decomposition for polyhedral morphing", The Visual Computer ,vol.15,No.9, pp.453-470,1999.
[51] Daniel Cohen et al.,"Three-Dimensional Distance Field Metamorphosis", ACM Transactions on Graphics (TOG) TOG Homepage archive,vol.17,Issue:2, pp.116-141,April 1998.
[52] Arthur Gregory,"Feature-based Surface Decomposition for Correspondence and Morphing between Polyhedra", Computer Animation 98 proceedings, pp.64–71, 1998.
[53]Ayellet Tal , Gershon Elber,"Image Morphing with Feature Preserving Texture", Computer Graphics Forum ,Volume 18, Issue:3,pp.339–348, September 1999.
[54] Anant M.Bagade,S.N.Talbar,"Image Morphing Concept for Secure Transfer of Image Data Contents over Internet", Journal of Computer Science 6(9):987-992,2010.