A Computational Skin Model: Fold and Wrinkle Formation

Nadia Magnenat-Thalmann, Prem Kalra, Jean Luc Lévêque, Roland Bazin, Dominique Batisse, and Bernard Querleux

***Abstract*—This paper presents a computational model for studying the mechanical properties of skin with aging. In particular, attention is given to the folding capacity of skin, which may be manifested as wrinkles. The simulation provides visual results demonstrating the form and density of folds under the various conditions. This can help in the consideration of proper measures for a cosmetic product for the skin.**

***Index Terms*—Aging, folding capacity, skin, wrinkles.**

I. INTRODUCTION

SKIN is a composite pseudosolid made of two main layers, (epidermis and dermis), which are themselves inhomogeneous in terms of structure and composition. The skin's first function is to contain the internal organs and muscles and to protect them from the eventual physical, biological, and chemical trauma caused by the environment. The skin is also a barrier ensuring the homeostasy of the internal medium by limiting, for example, the evaporation of the internal water. Finally, skin is a sensitive organ containing different receptors specialized in the detection of thermal and/or mechanical stimuli and pain.

Furthermore, due to its outside visibility and aesthetic value, people tend to give a lot of attention to skin. It is a challenging task to accurately model the appearance of skin and its detailed behavior; this modeling has a variety of applications from entertainment to cosmetics and plastic surgery.

During the last 30 years, several noninvasive *in vivo* physical methods were proposed to describe the skin's viscoelastic properties. *In vitro* methods in previous publications have also given precise information on the stress-strain relationship and the relaxation and creep processes taking place in skin. These studies allow us to know which parameters can influence the skin properties (site, orientation, age, pathology, thickness, etc.), but have failed to relate them to the main elements of the skin's structure. In that respect, the different attempts to model a skin's mechanical properties by combining different rheological elements (spring, dashpots, etc.) only provided an approximate fitting of the experimental curves with the mathematical expression of these models. In addition, they did not provide any information about the influence of the different skin layers or the importance of the different skin components on the skin's global properties.

This paper focuses on the skin simulation concentrating on both the visual and biomechanical aspects. In particular, this paper concerns, in a first instance, the design of a computational multilayer skin model relevant for assessing the folding capacity of the skin with age. Further, a comparison with experimental measurements is presented. The physical characterization of the folds appearing in such conditions in a young population versus an old one, demonstrates that folds are numerous and of low amplitude in young skin but fewer and of higher amplitude in aged. The primary concern here is to study the behavior of wrinkle formation and its correlation with certain physical properties and their variation with age as opposed to the visual realism of the skin surface considered in the earlier work [1]. The present study is related to skin modeling pertinent to cosmetic and skin care. We believe that this model may also be relevant for plastic surgery, where wrinkles and folds are treated.

This paper is organized as follows. First, we provide some background on the skin and wrinkle physiology (wrinkles are, in some sense, the manifestation of the folding capacity of skin). Then, some related work in connection with the study and computational models for simulating and visualizing the various effects are briefly described. The relevant data with the acquisition process for the present study is provided in Section IV. Next, our skin model and the simulated results are presented. Finally, we give some concluding remarks.

II. SKIN AND WRINKLE PHYSIOLOGY

Though our intention here is not to model and simulate the exact biological form and functions of human skin, it is, however, important to study and analyze the skin's physiology in order to determine the relevant properties that are necessary for realistic skin modeling and simulation.

A. Skin Composition and Structure

The skin accounts for about 16% of the body weight [2], has a typical surface area of 1.5 to 2.0 m^2 in adults, and has a thickness from 0.2 mm (eye lids) to 6.0 mm (sole of foot).

The skin consists of three layers: the epidermis, dermis, and hypodermis. The epidermis thickness ranges between 50 to 100 μm. It is composed of a "dead" layer of cells called "stratum corneum" (10 to 20 μm thick on most of the body surface). These cells are flat and mainly composed of keratin, a quite rigid and hard material. The stratum corneum forms a protective shield for covering the underlying viable epidermis composed primarily of keratinizing epithelial cells. This "horny

Manuscript received December 20, 2000; revised June 20, 2001. Manuscript accepted December 21, 2001.

N. Magnenat-Thalmann is with MIRAlab, University of Geneva, CH1211 Geneva, Switzerland (e-mail: thalmann@miralab.unige.ch).

P. Kalra, J. L. Lévêque, R. Bazin, D. Batisse, and B. Querleux are with Loreal, Chevilly La Rue, France (e-mail: jlleveque@rechere.loreal.com; rbazin@rechere.loreal.com; dbatisse@rechere.loreal.com; bquerleux@rechere.loreal.com).

Digital Object Identifier 10.1109/TITB.2002.806097

layer" is the result of two biological processes: differentiation and proliferation of keratinocytes that compose the living epidermis. The dermis, depending on the anatomical sites, is mainly composed of collagen and elastin fibers embedded in a viscous medium made of water and glycoproteins. Fibers of the upper dermis (or "papillary dermis") are thinner than those present in the deep dermis. Total thickness varies according to the site from 1 to 3 mm. Hypodermis is quite variable in thickness depending on the person, and the position on the body; it is mainly composed of cells (adipocytes).

B. Mechanical Properties and Aging

The important mechanical properties of the skin are extensibility, resistance to friction, and response to lateral compressive loading [2]. Skin properties vary with species, age, exposure, hydration, obesity, disease, site, and orientation. The other material properties of skin are nonlinearity, anisotropy, and visco-elasticity, incompressibility, and plasticity [3].

The aging process considerably alters both the structure and the mechanical properties of skin. Aged skin is less extensible and less elastic than adult skin [4]. These alterations could be related to important modifications occurring in the upper dermis where fibers are markedly modified, thinned and/or fractionated as revealed by ultrasound imaging [5] and ultrastructural [6] studies. In addition, ultrasound imaging studies have demonstrated the existence of a poor echogenic layer located in the upper dermis; the thickness of which increases with age [5].

C. Lines, Wrinkles, and Folds

As skin changes with age, wrinkles emerge and become more pronounced. Wrinkles depend on the nature of skin and muscle contraction; in this article two types of wrinkles are considered: expressive wrinkles (particularly relevant for the face) and wrinkles due to age. Folds appear when skin is deformed but disappear after removal of the deformation. Repetition of skin folding on the same site would progressively give rise to permanent wrinkles. Wrinkles are important for understanding and interpreting facial expressions and can provide some indication of the age of a person.

III. RELATED WORK

Changes in the mechanical properties of skin versus age have been extensively studied with noninvasive physical methods in the last decade [4], [7]–[9]. After a long period of debate on some conflicting results, most of the specialists now agree on the following points: 1) the elastic part in the total strain of skin (after the application of a given stress) is reduced in aged skin, 2) the total strain is reduced. This means that the elastic modulus is increased. This elastic modulus ranges from 0.2 to 3 MPa [8], and during aging it increases by about 30%.

Not much work has been done in the computer simulation and visualization of human skin in general, although some work has been done in the simulation of facial skin deformation. Various models have been proposed to simulate facial animation and skin deformation for different purposes [10], and some of these models could be extended to any part of the body. These are geometric models, physically based models, and biomechanical models using either a particle system or a continuous system. Many geometrical models have been developed, such as parametric model [11], [12], geometric operators [13] and abstract muscle actions [14]. There are also different kinds of physically based models, such as the tension net model [15] and the three-layered deformable lattice structure model [16], [17]. The finite-element method has also been employed for a more accurate calculation of skin deformation, especially for potential medical applications such as plastic surgery [18]–[20]. Some work based on finite-element methods has also been reported on the Internet [21], [22]; however, not many details are provided. There are a few animation models with dynamic wrinkles; Viaud *et al.* [23] have presented a geometric hybrid model for the formation of expressive and aged wrinkles, where bulges and folds are modeled as spline segments and determined by an age parameter. There are also physically based facial animation models, where some wrinkles appear as the outcome of the skin deformation [11], [24].


(a)


(b)

Fig. 1. Skin folds (a) young (b) old skin.

IV. FOLDING PROPERTIES OF SKIN: RECENT FINDINGS

Recently, a new experimental approach was developed to describe, quantitatively and clinically, the changes in the skin properties versus age. It consists of compressing the skin horizontally by using a quite simple original device called Densiscore [31]. The skin compression ratio was found to be 40% when considering the experimental zone to be the dorsal site of the arm [9]; by quantifying the width of the folds generated by the compression process, it has been demonstrated that folds are thin and numerous in a young population and wider but fewer in an old population (see Fig. 1). According to this work, these changes in the folding capacities of skin could be related to the existence of a region in the upper dermis of aged persons, where collagen and elastin are less dense and only present under thinner bundles, compared to the upper dermis of a young population. This interpretation is also supported by previous work, now generally accepted, describing a nonechogenic (or weakly echogenic) zone that is taking place in the upper dermis region, as viewed in the ultrasound images of skin [5]. A supplementary measurement of the changes in the folding properties of skin versus age comes from the measurement of the elastic extensibility of the stratum corneum and of the total skin assessed by a torsional device. In both cases, extensibility is reduced in the aged population, which can be interpreted by an increase of the "elastic modulus" of the two tissues (thickness of stratum corneum and total skin are constant).

Such results, clinically and objectively supported, can be used to check the validity of any mathematically based models. The interest of such a model is not only to fit with the experimental data (which is the minimum requirement), but also to help in foreseeing the influence of other skin parameters, present in the model (different layers thickness or the shape of the dermal-epidermal junction etc.), which can hardly be modified by simple skin treatments.

V. SKIN MODEL

In many of the earlier models, the skin had no real thickness; it was basically modeled as an elastic membrane [25]. The incompressibility was treated in a "loose" manner and the system relies on user inputs in many cases. In addition, these earlier approaches required the specification of wrinkle lines with their locations [25]. However, for a realistic simulation, wrinkles need to be simulated with all of the properties that contribute to their equilibrium state. The proposed model is devised by taking into account some of these issues; we consider the different layers of the skin with each given thickness and their mechanical properties such as elastic modulus and Poisson ratio. The model is intended to provide the different characteristics of wrinkles: location, number, density, cross-sectional shape, and amplitude, as a consequence of skin deformation caused by a muscle action.

A. Layered Structure

The skin is considered as layers of different type of tissues having different properties as shown as a cross section in Fig. 2. This multilayer notion corresponds to the reality, as previously described. The layered structure provides the notion of each layer having substance and therefore allows the preservation of the volume. The entire medium is meshed into triangles with different layers as shown in Fig. 3.

B. Skin Deformation Model

The behavior of tissue is controlled by elastic deformation; that is, each layer here is considered as a linear, isotropic, elastic material. By using Hooke's law, strains are measured along the principal axes; the principal axes are found by using only a few geometric operations aligning the original and deformed triangle and computing the oriented bounding box or ellipse to the triangle. The major and the minor axes, therefore, provide the two principal axes. The advantage of measuring strains along the principal axes is that we do not have to account for the shear strain in an explicit manner. The principal stresses are computed using Hooke's law as follows [26]:

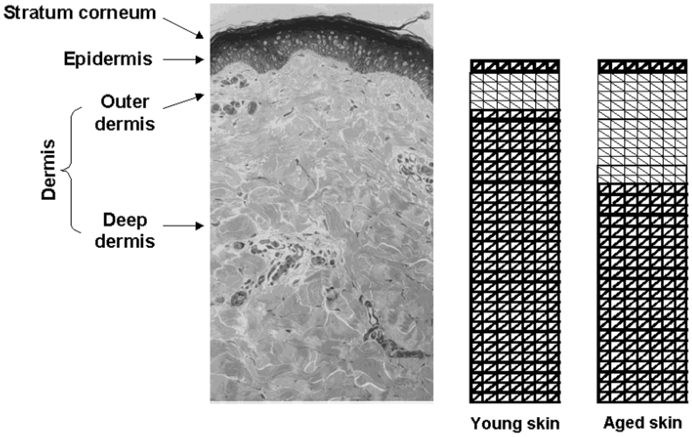

Fig. 2. Multilayer aspect of the skin computational model.

$$\sigma_1 = \frac{E}{(1-\nu^2)}(\varepsilon_1 + \nu\varepsilon_2) \quad \text{and} \quad \sigma_2 = \frac{E}{(1-\nu^2)}(\varepsilon_2 + \nu\varepsilon_1)$$

where E is the Young's modulus, ν the Poisson ratio, and ε_1 and ε_2 are the principal strains.

Once the in-plane stress has been computed, it is then converted to the forces at the vertices (nodes) of the triangle. A constant mass is assumed, and distributed over the triangle and the acceleration is determined using Newtonian mechanics. The term of acceleration is then integrated using an implicit method [27] to obtain the new position of the triangle vertex.

C. Wrinkle Simulation

The model allows for the simulation of both the temporary and permanent wrinkles. In the following sections, we provide the basic concept for the simulation of the two types.

1) Temporary Wrinkles: In previous models, simulations are performed on an abstract, simplified, piece of skin. The process of deformation does not use explicit definition of a muscle in the current simulation. The two ends, whose position is a consequence of a muscle action, act as input to the simulation. The upper surface layer responds to this compression with bulging out of its original line, whereas, the underlying layer regulates this deformation. In other words, where the surface bulges up, the underlying tissue stretches (extends vertically, shortens horizontally), and where the surface bulges down, the underlying tissue squeezes (shortens vertically, extends horizontally). These deformations appear in a periodic pattern, ending up with a sinusoid like line of the surface as illustrated in Fig. 3.

Such a sinusoidal pattern does not show enough similarity to wrinkle. The cross-sectional curve of real wrinkles has similar hills, but sharp valleys in contrast to these smooth ones. We achieve this more realistic type of wrinkle cross-section by using a sinusoidal interface between the two layers (Fig. 4). It is also observed in the real structure of skin that the interface between epidermis and dermis is not flat, rather it is close to a sinusoidal curve, as shown in Fig. 2.

2) Permanent Wrinkles: Every triangle that the tissues consist of has a shape memory, i.e., its rest shape. We can introduce

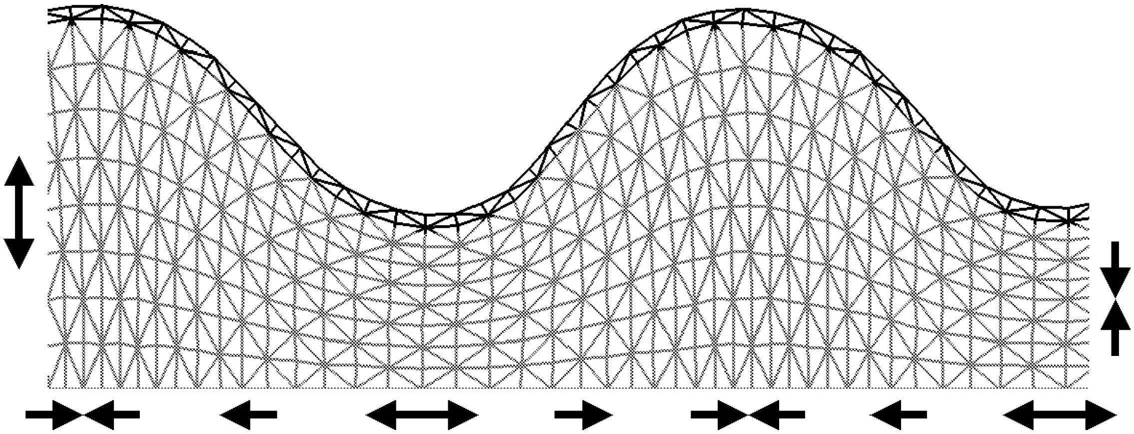

Fig. 3. Concept of temporary wrinkle generation.

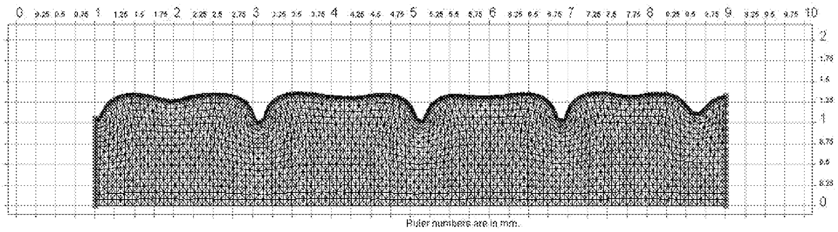

Fig. 4. Simulation result using a sinusoidal interface between the two tissues.

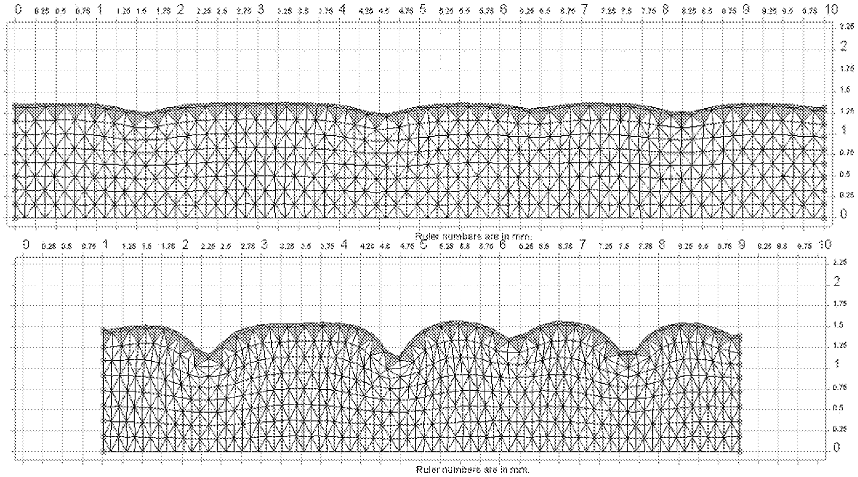

Fig. 5. Effect of plasticity factor in the formation of wrinkles.

plasticity effects into this model by constantly adjusting the rest shapes of the triangles based on the current deformations. This causes a slow adaptation to the deformations with a new rest shape. As a result, the overall shape of skin reflects its history. In addition, it is observed that the wrinkles that are formed, naturally guide the location of future wrinkles. Fig. 5 illustrates the influence of the plasticity factor.

D. Experimental Results

1) Two-Layer Skin Model: In a first approach, we looked at the folds of compressed skin in a two-layer model (epidermis and dermis). This model demonstrated that the modulus of the second layer (the dermis) should be decreased in aged persons in order their skin displays the characteristic folding aspect; as is found from clinical tests. However, this model leads to a contradiction between the prediction of the folding capacity of

TABLE I
SKIN PROPERTIES FOR YOUNG AND AGED PEOPLE

	Young	Aged
First Layer		
a) Thickness	0.015	0.015
b) Modulus	6	12 (dryer stratum corneum)
Second Layer		
c) Thickness	0.050	0.2
d) Modulus	0.05	0.05
Third Layer		
e) Thickness	1.235	1.085
f) Modulus	0.6	1 (total skin thickness is 1.3, constant)

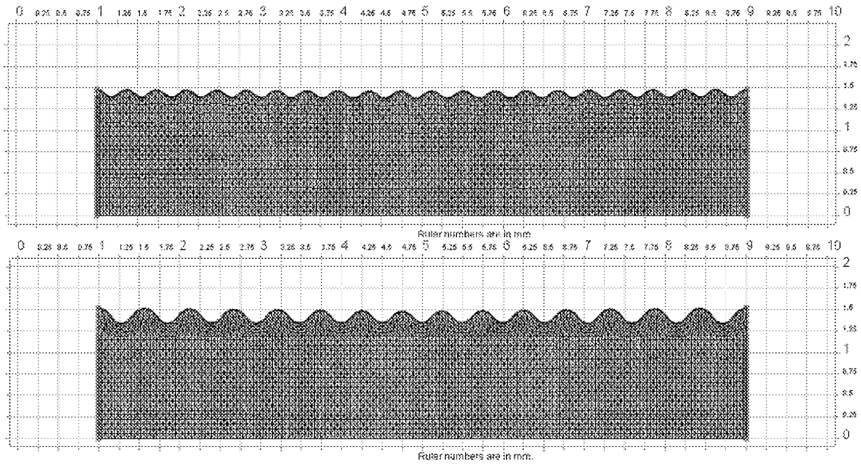

Fig. 6. Simulation of a three-layer model representing young and old skin.

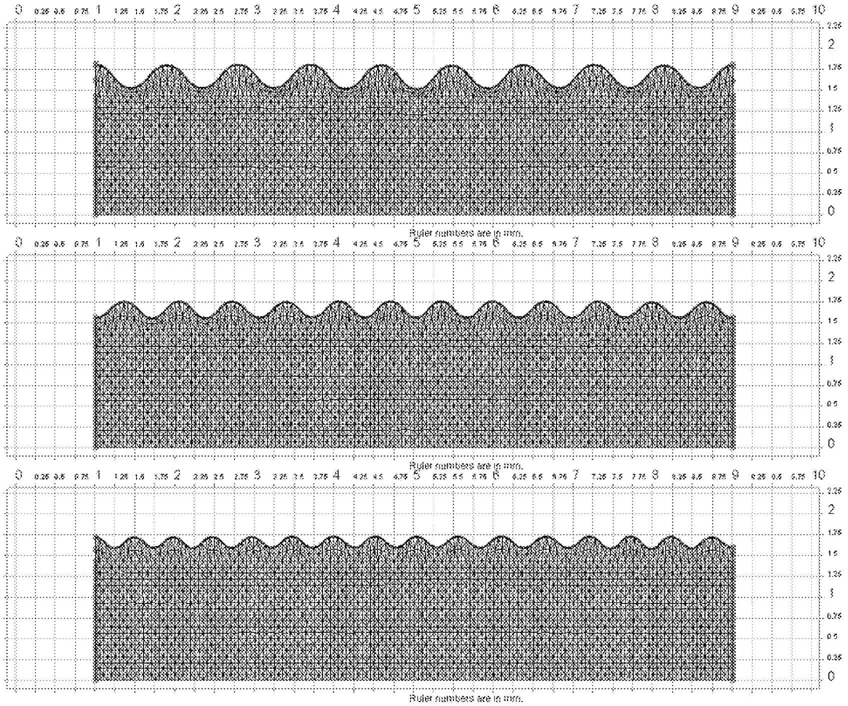

Fig. 7. Effect of the hydration on the stratum corneum in old skin (decreasing the elastic modulus of the first layer).

aged skin and the actual clinical observations. This model predicts the folding properties in accordance with the clinical findings only if the Young modulus of the second layer (dermis) is lower for aged than for young skin. This is contradictory to the evidence presented in relevant literature [4], [7], [8].

2) Three-Layer Skin Model: By taking into account the results of two-layer model, which was found in contradiction with the actual properties of aged skin, we tried a three-layer model. In such a model, Layer One is the stratum corneum, the modulus of which is roughly 100 times higher than of the dermis (when it is dry) and is highly dependant on its water content [28]. Layer Two is the part of skin corresponding to both the living epidermis and the subepidermal nonechogenic band (SENEB) as defined by De Rigal *et al.* [5], and is composed of thin and fractionated fibers of elastin and collagen. This part of skin would have a very low elastic modulus and would explain the loss of skin elasticity in aged skin [29]. It is well known that the thickness of the living epidermis is only marginally modified up until the age of seventy [30] although SENEB markedly increases in aged skin and can represent more than half the skin [28]. The total skin thickness is relatively constant up until 65 years of age. In this model, the third layer is the deep dermis.

The main hypothesis made in this case concerns the value attributed to the Young modulus of the second layer. There is no data in the literature concerning living epidermis or papillary dermis. What is almost certain is that these tissues, mostly composed of living cells (epidermis) and thin fibers embedded in an aqueous medium (upper dermis) have a much lower Young modulus than both stratum corneum and reticular dermis. Differences in the skin parameters between young and aged skin are summarized in Table I.

With such parameters, the values of which are supported by literature references and by the results of our last clinical study, the three-layer model predicts quite well the clinical aspects of the skin folding, as can be seen in Fig. 6.

It is interesting to look more systematically at the influence of the different parameters on the aspect of the folds. For example, the decrease of the first layer modulus of about 50%, which would correspond to a hydration of the stratum corneum, has as a consequence a quite marked change in the folds which appear lower in amplitude and more numerous, as illustrated in Fig. 7. Such changes are in accordance the clinical observations after treating the skin with an efficient cosmetic product.

It is worth noting, that even with the introduction into the model of a second layer having a very low modulus, the total skin modulus is higher for aged than for young skin. It may be noted that in our simulation we have considered Poisson's ratio as 0.5 for each layer.

VI. CONCLUSION

This paper presents a computational model of skin to predict its folding capacity under longitudinal compression. A layered structure is used for modeling skin, where each layer may have different biomechanical properties. Two approaches have been employed. First, we consider a two-layer model, and observe a contradiction with respect to the actual properties of skin Young modulus of the second layer (dermis); where it is lower in the case of aged skin than for young skin. In the second approach we consider a three-layer structure and notice that the model is pretty much in accordance with the clinical observations. The model developed is not tailored for real-time applications; however, we plan to investigate its suitability as part of our future work.

ACKNOWLEDGMENT

The authors would like to thank G. Kiss for his early work and C. Joslin for proofreading this paper.

REFERENCES

[1] L. Boissieux, G. Kiss, N. Magnenat Thalmann, and P. Kalra, "Simulation of skin aging and wrinkles with cosmetics insight," *Computer Animation and Simulation*, pp. 15–27, 2000.

[2] Y. Lanir, "Skin mechanics," in *Handbook of Bioengineering*, R. Skalak, Ed. New York: McGraw-Hill, 1987.

[3] M. Walter, Y. Wu, N. Magnenat Thalmann, and D. Thalmann, *Biomechanical Models for Soft Tissue Simulation*, ser. Esprit. New York: Springer-Verlag, 1998.

[4] C. Escoffier, J. de Rigal, and A. Rochefort, "Age related mechanical properties of human skin," *J. Invest. Dermatol.*, vol. 93, pp. 353–357, 1980.

[5] J. De Rigal, C. Escoffier, and B. Querleux, "Assessment of aging of the human skin by *in vivo* ultrasonic imaging," *J. Invest. Dermatol.*, vol. 93, pp. 621–625, 1989.

[6] E. F. Bernstein, P. Hahn, and J. Uitto, "Long term sun exposure alters the collagen of the papillary dermis. Comparison of sun protected and photo-aged skin by northern analysis, immunohistochemical staining and confocal laser scanning microscopy," *J. Amer. Acad. Dermatol.*, vol. 34, no. 2, pp. 209–218, 1996.

[7] Y. Takema, Y. Yorimoto, and M. Kawai, "Age related changes in the elastic properties and thickness of human facial skin," *Brit. J. Dermatol.*, vol. 131, pp. 641–648, 1994.

[8] Serup and Gemec, Eds., *Handbook of Non-Invasive Methods and the Skin*. Boca Raton, FL: CRC, 1995.

[9] D. Batisse, R. Bazin, and T. Baldeweck, *Age Related Changes in the Folding Capacity of the Skin*. Geneva, Switzerland: European Academy of Dermatology and Venereology, 2000, pp. 11–15.

[10] F. I. Parke and K. Waters, *Computer Facial Animation*. Wellesly, MA: AK Peters Ltd., 1996.

[11] F. I. Parke, "A parametric model for human faces," Ph.D. dissertation, Univ. Utah, Salt Lake City, 1974.

[12] ——, "Parametric model for facial animation," *IEEE Comput. Graphics Applicat.*, vol. 2, no. 9, pp. 61–68, 1982.

[13] K. Waters, "A muscle model for animating three dimensional facial expression," *Proc. SIGGRAPH, Comput. Graphics*, vol. 21, no. 4, pp. 123–128, 1987.

[14] N. Magnenat Thalmann, E. Primeau, and D. Thalmann, "Abstract muscle action procedures for human face animation," in *The Visual Computer*. New York: Springer-Verlag, 1988, vol. 3, pp. 290–297.

[15] S. Platt and N. Badler, "Animating facial expressions," in *Proc. SIGGRAPH*, vol. 15, 1981, pp. 245–252.

[16] D. Terzopoulos and K. Waters, "Physically-based facial modeling and animation," in *J. Visualization Computer Animation*. New York: Wiley, 1990, vol. 1, pp. 73–80.

[17] Y. Lee and D. Terzopoulos, "Realistic modeling for animation," in *Proc. SIGGRAPH*, 1995, pp. 55–62.

[18] W. F. Larrabee, "A finite element method of skin deformation: I. Biomechanics of skin and soft tissues," *Laryngoscop.*, vol. 96, pp. 399–405, 1986.

[19] S. Pieper, "CAPS: Computed-Aided Plastic Surgery," Ph.D. dissertation, Dept. Media Arts and Sciences, Massachusetts Inst. Technol., Cambridge, 1992.

[20] R. M. Koch, M. H. Gross, F. R. Carls, D. F. Von Buren, G. Fankhauser, and Y. I. Parish, "Simulation facial surgery using finite element models," in *Proc. SIGGRAPH, Comput. Graphics*, 1996, pp. 421–428.

[21] Skin Group, Univ. Glasgow., Glasgow, U.K.. [Online]. Available: http://www.dcs.gla.ac.uk/~jc.

[22] Virtual Face Movie.. The University of Auckland, New Zealand. [Online]. Available: http://www.esc.auckland.ac.nz/Groups/Bioengineering/Movies/index.html.

[23] M. Viaud and H. Yahia, "Facial animation with wrinkles," in *Proc. 3rd Workshop on Computer Animation and Simulation*. Cambridge, U.K.: Eurographics, Springer-Verlag, 1992.

[24] Y. Wu, N. Magnenat Thalmann, and D. Thalmann, "A plastic-visco-elastic model for wrinkles in facial animation and skin," in *Proc. Pacific Conf.*. Singapore, 1994, pp. 201–213.

[25] Y. Wu, P. Kalra, L. Moccozet, and N. Magnenat Thalmann, "Simulating wrinkles and skin aging," *Visual Comput.*, vol. 15, pp. 183–198, 1999.

[26] S. P. Timoshenko and J. N. Goodier, *Theory of Elasticity*. New York: McGraw-Hill, 1982.

[27] P. Volino and N. Magnenat-Thalmann, "Implementing fast cloth simulation with collision response," *Computer Graphics International*, pp. 257–266, 2000.

[28] B. F. Van Duzee, "The influence of water content, chemical treatment and temperature on the rheological properties of stratum corneum," *J. Invest. Dermatol.*, vol. 71, no. 2, pp. 40–44, 1978.

[29] J. De Rigal, S. Richard, and O. De Lacharriere, "*In vivo* assessment of skin aging and photo-aging: A multi-parametric approach," in *Int. Symp. Bioeng. Skin*, 1996.

[30] F. Timar, G. Soos, and B. Szende, "Interdigitation index—A parameter for differentiating between young and older skin specimens," *Skin Res. Technol.*, vol. 6, pp. 17–20, 2000.

[31] R. Bazin, R. Pozzo Di Borgo, A. Bouloc, M. L. Abella, J. P. Hirt, and M. De Troja, "Densiscore, a new tool for clinical evaluation of age dependant mechanical properties of female skin," in *Proc. 20th World Congr. Dermatology*, 2002.

Nadia Magnenat-Thalmann received the bachelor degrees including psychology, biology, and computer science and the M.Sc. degree in biochemistry in 1972 and the Ph.D. degree in quantum physics in 1977, all from the University of Geneva, Geneva, Switzerland.

She has pioneered research into virtual humans over the last 20 years. From 1977 to 1989, she was a Professor at the University of Montreal in Canada. In 1989, she founded MIRALab, an interdisciplinary creative research laboratory at the University of Geneva.

Prem Kalra received the Ph.D. degree in computer science from the Swiss Federal Institute of Technology, Lausanne, Switzerland, in 1993.

From 1989 to 1997, he was with MIRALab, University of Geneva, Geneva, Switzerland. He is currently an Associate Professor in Department of Computer Science and Engineering at the Indian Institute of Technology (IIT), Delhi, India. He has published about 40 papers in the various international journals and conferences. His research interests include 3-D visualization, image-based rendering and animation, human face modeling and animation, and virtual reality.

Jean Luc Lévêque received the Ph.D. degree in physics from the University of Grenoble, Grenoble, France, in 1968.

He was Director of the Biophysics Department with the L'Oréal Company for 25 years. Presently, he is Directeur de la Prospective with the General Management of L'Oréal-Recherche, Clichy, France. He is author of about 200 publications relative to the physical properties of hair and skin.

Roland Bazin received the biophysical engineer degree from the Ecole Nationale Supérieure de Micromécanique et Microtechnique de Besançon, France, in 1974.

He was with the Dermatology Service at the University Hospital Center of Besançon for eight years, in the Vascular and Cutaneous Functional Explorations Service. Since 1985, he has been head of the Instrumental Skin Care Evaluation Service within the Make Up, Skin Care, and Perfume Evaluation Department of L'Oréal, Chevilly La Rue, France.

Dominique Batisse received the Ph.D. degree in physics from Mulhouse University, Mulhouse, France, in 1995.

He is in charge of the development of measurement methods to characterize the effects of skin care products within the Make Up, Skin Care, and Perfume Evaluation Department of L'Oréal, Chevilly La Rue, France. He worked for the French Defence Ministry for four years on the measurement of dynamical toughness of adhesives.

Bernard Querleux was born in France in 1957. He received the Diploma degree in electronic engineering and the Ph.D. degree in electronic engineering and signal processing from the University of Grenoble, France, in 1983 and 1987, respectively.

He is currently a Senior Researcher in the advanced research laboratories of L'Oréal Group, Aulnay sous Bois, France. His research interests include noninvasive methods for skin imaging, image processing with applications in ultrasound, and magnetic resonance imaging.