

Quantitative Analysis of Facial-Expression Training Application for Medical Doctors

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Abstract— Establishing trust between a patient and a doctor depends as much on their relationship as on the doctor's medical abilities. One of important factors in building and maintaining a relationship is whether the doctor produces facial expressions appropriate for the patient's condition. We developed a facial-expression training application for medical students and tested its effectiveness as a training tool. In this application, Microsoft Cognitive Services Emotion API is used to analyze the facial expression. Prior to developing this application, we studied what kind of facial expressions were appropriate in a doctor-patient greeting situation. We focused on four conditions for practicing facial expressions. Three of them are greetings given by doctors at the beginning of medical interviews of adult patients in a general ward of a hospital. The fourth is a medical scenario in which a doctor puts a stethoscope to a patient's chest, i.e., auscultation. To verify the training application's effectiveness, the facial expressions before and after learning with the application were evaluated by potential patients. The results confirmed the application's utility.

Keywords-doctor-patient interaction; facial expression; nonverbal communication; facial-expression training application.

I. INTRODUCTION

Patient satisfaction is an important component of medical care [1]. Improving patient satisfaction enhances trust and the relationship between patient and doctor, which leads to stronger adherence to prescribed protocol, such as taking medicine, and to enhanced therapeutic effects [2][3]. Many studies and reviews have shown that the main determinant of patient satisfaction is the patient-doctor relationship [4]–[8] and that patient satisfaction is higher when the patient communicates with a doctor who has strong nonverbal-communication skills [9][10]. However, young inexperienced doctors and medical students often have trouble producing appropriate facial expressions when greeting a patient. The first author of this paper, a lecturer on medical communication, often hears young doctors complaining that, though they intend to smile, patients say that they seem angry.

In response to these troubles, we developed a facial-expression training application that physicians can use for independent-study. In this application, Microsoft Cognitive Services Emotion API is used to analyze the facial

expression. Prior to developing this application, we quantitatively clarified acceptable expressions required when doctors treat patients by comparing human evaluation results with those of a computer system [11]. The results were incorporated into the application as model expressions. These model expressions are standards to compare with those of learners using the application. Then, to verify the effectiveness of the application, learners' facial expressions before and after learning with the application were evaluated by potential patients. The evaluation results confirmed the utility of the application.

After introducing related work in Section II and previous work in Section III, we describe the system of the facial-expression training application in Section IV. We discuss the results of our experiments in Section V. Section VI gives our conclusion, and Section VII considers future work.

II. RELATED WORK

A. Nonverbal Communication

Medical interviews have traditionally focused on gathering relevant information from patients [12]. In contemporary medicine, the focus has expanded to building a trusting relationship, sharing decision-making, responding to the patient's emotional state, and supporting actions related to the patient's condition and treatment; this requires the doctor to have a wide range of communication skills [13]. These skills include “looking at a patient not as a case but as a human being” [14] and “building and maintaining a good relationship between doctor and patient” [15]. It has been shown that such skills have a greater effect on patient satisfaction than the doctor's medical skills, the medicine prescribed, the information provided, the questions asked, and the advice and instructions given. In particular, a patient's satisfaction is positively related to the doctor being warm [14]–[16], empathic [14][16]–[18], friendly [16], and giving the impression of being human [17].

Nonverbal communication is a means of communicating these emotional aspects of oneself. Patient satisfaction is higher when the doctor has a strong ability to express his or her emotions and to read the emotions of others through nonverbal cues such as facial expressions, gaze, posture, and tone of voice [9][19][20]. In short, a doctor's nonverbal communication is an important aspect of patient care.

B. Learning Facial Expressions

Natural, unconscious facial expressions can be seen in humans from infancy [21], but eventually conscious expressions appear. Conscious expressions might also be thought of as “false” expressions. These expressions are skills that form the basis of more complicated expressive behaviors, such as emotional expressions performed in accordance with rules in communication situations [22].

Facial expressions as expressions of emotion are thought to be founded in an understanding of emotions, and there are many developmental studies about understanding emotions. However, studies about learning facial expressions are mostly focused on social-skills training for children with developmental disabilities, and there are not many studies for adults.

In one study, participants were required to express other people’s facial expressions by recalling emotions and showing photos of faces with emotions, the showing photos effect was shown about “anger” [23].

In research to develop a smile-training system with the goal of training participants to produce celebrity-like smiles (a facial expression recognized as attractive) [24], researchers created a smile-fitted deformation considering the characteristics of a celebrity-like smile in participants’ expressionless faces. As a result of training, participants were able to express a smile highly likely to be recognized as attractive by others.

From the above, it is clear that presenting appropriate facial-expression images is effective for facial-expression training as both a method of expressing emotions and a learning method.

III. PREVIOUS WORK

A previous study [11] has revealed what are considered acceptable facial expressions for a doctor in accordance with the patient’s condition. One way to analyze appropriate facial expressions for doctors is to define the facial expressions of experienced doctors. However, their facial expressions are not always deemed appropriate. Also, because many young physicians have trouble presenting appropriate facial expressions when greeting a patient, we chose to find facial expressions that would be acceptable for most patients, including potential patients, from facial expressions that medical students think are suitable. We chose greeting patients in the general ward of a hospital as the target situation.

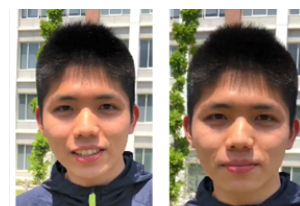
The procedure was as follows. The participant roleplaying the patient portrayed three conditions: a patient who feels physically healthy (a “bright patient”), one whose physical condition is unknown (an “expressionless patient”), and one who feels badly and is suffering pain (a “patient in pain”). We photographed these roleplayed conditions. Then, a plurality of medical students greeted the three photographs with the facial expressions that each student deemed appropriate, and we recorded video of them doing so. Comparing an evaluation by adults and analytical results from a computer of the medical student’s greeting movies revealed what were considered the acceptable facial

expressions in accordance with the patient’s condition. The acceptable facial expressions when a young doctor greets an adult patient who is hospitalized in a general ward are as follows. For patients who feel physically healthy, the most acceptable facial expression is Figure 1; “continuous happiness” (expressed more as a laugh rather than simply a smile). For patients without a facial expression, the most acceptable facial expression is Figure 2; initially “happiness” (expressed as a smile) and then “neutrality” (expressionlessness).



Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:00.7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:01.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:01.7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 1. Acceptable facial expression for patients who feel physically healthy.



Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.34
00:00.7	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.29
00:01.2	0.79	0.00	0.01	0.00	0.00	0.00	0.00	0.20
00:01.6	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.06
00:02.2	0.35	0.00	0.01	0.00	0.00	0.00	0.00	0.63
00:02.7	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.07
00:03.2	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.76
00:03.8	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.70
00:04.0	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.59

Figure 2. Acceptable facial expression for patients without a facial expression.



Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.7	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.93
00:01.1	0.00	0.00	0.00	0.00	0.00	0.06	0.02	0.92
00:01.6	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.96
00:02.2	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.92
00:02.6	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.66
00:00.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
00:03.2	0.00	0.01	0.02	0.00	0.00	0.13	0.00	0.84
00:03.6	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.94
00:03.0	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.92

Figure 3. Acceptable facial expression for patients in bad physical condition suffering pain.

For patients in bad physical condition suffering pain, the most acceptable facial expression is Figure 3; “neutrality” with a little “sadness” or “surprise”. The cells in the Figure1-3 corresponding to 0 or more and less than 0.2 are shown in blue, 0.2 or more and less than 0.4 in green, 0.4 or more and less than 0.6 in yellow, 0.6 or more and less than 0.8 in orange, and 0.8 or more in red. The total for all emotions is 1, and the value for neutrality is obtained by subtracting the total value for the seven emotions from 1.

IV. FACIAL-EXPRESSION TRAINING APPLICATION SYSTEM

A. Requirements and Design Concept

Learners study in the following order so that the appropriate facial expressions can be learned efficiently and repeatedly. When starting, to enable learners to notice what their facial expressions are before training, the system has them greet with expressions that they think are suitable without any specific instructions.

- Step 1: A learner chooses one of the model patients.
- Step 2: The learner greets the model patient with a facial expression that the learner thinks appropriate, and this greeting is recorded.
- Step 3: A video of the model doctor greeting the patient with the appropriate facial expression and analysis data are displayed, and important points to notice about the appropriate facial expressions are introduced.
- Step 4: The video recorded in Step 2 and its analysis data are displayed.
- Step 5: The learner repeats from Steps 2 to 4 until satisfied.
- Step 6: If the learner is satisfied, the learner selects a patient with a different condition and returns to Step 1.

In the developed system, in addition to being able to check the facial expressions the learner performed by recording them as a video, the learner can also check the quality of his or her expression on a frame-by-frame basis. Each learner can save images as learning data and facial-expression analysis results by applying security processing because these data and analysis results are important as research data.

B. System Configuration

We developed and used a system that quantitatively analyzes changes in facial expression. It is based on the Cognitive Services Emotion API [25] provided by Microsoft’s Azure cloud service, and a facial-expression-emotion detection system for video images. Our facial-expression-emotion analysis system calculates the ratio for seven emotions (happiness, anger, contempt, disgust, fear, sadness, and surprise) reflected in the input video image and for neutrality. The total for all emotions is 1, and the value for neutrality is obtained by subtracting the total value for the

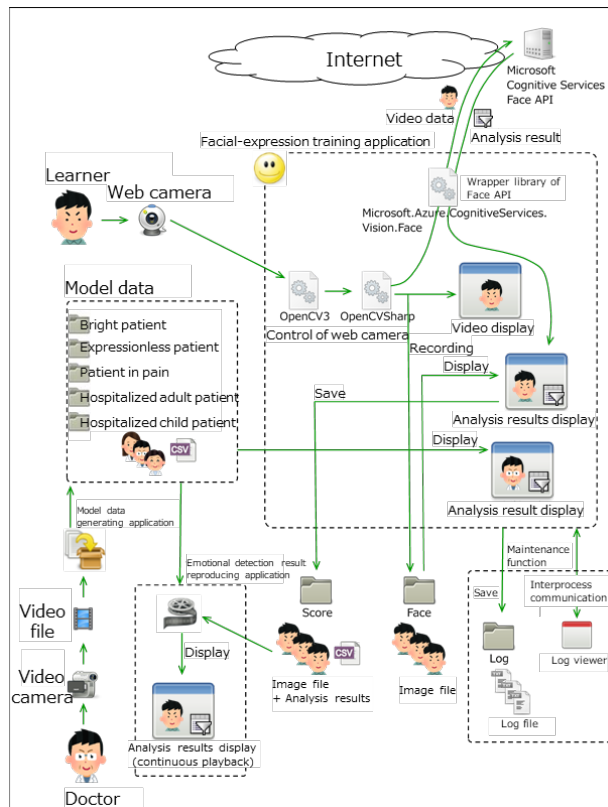


Figure 4. Configuration of facial-expression training application.

seven emotions from 1. The configuration of this application is as shown in Figure 4. A video camera is controlled by the Open CV [26]. Recorded video data are converted the Motion-JPEG, and send to the Cognitive Services Emotion API.

At first, the learner selects a patient to be a training partner in Figure 5. After clicking the recording button, the learner talks to the model patient. When the greeting and consultation is over, the learner clicks the stop button followed by the next button in Figure 6.

The emotional values of the model doctor’s facial expression are displayed. By selecting a timeline, the corresponding facial expression is displayed in Figure 7.

The emotional values of the learner’s facial expression are displayed. By selecting a timeline, the corresponding facial expression is displayed in Figure 8.



Figure 5. Step 1: Patient-selection screen.



Figure 6. Step 2: Learner greets and examines patient while screen is recorded.

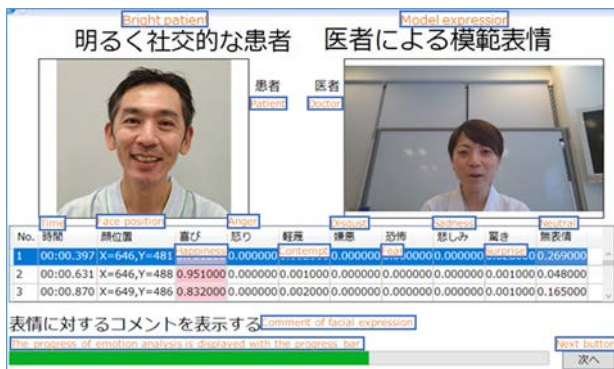


Figure 7. Step 3: Model doctor's appropriate facial expression and analysis results.

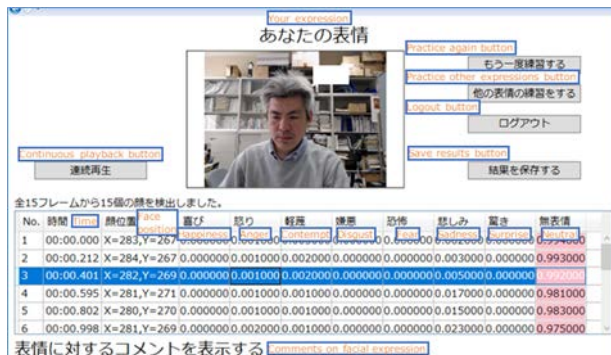


Figure 8. Step 4: Analysis of image taken in Step 2.

C. Model Doctors

Videos of model doctors were prepared with the following procedure. In a previous study [11], the acceptable doctors' expressions for the patients were measured and selected. The model doctors (one male and one female) reproduced the acceptable facial expressions, and their reproductions were recorded as videos. Seventy-nine people evaluated these videos of Figure 9–11 and confirmed that they were appropriate, so we adopted them as the model doctor videos.

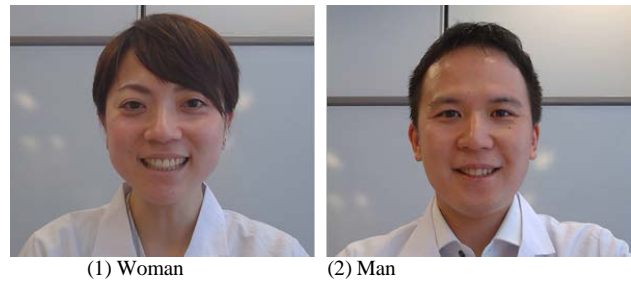


Figure 9. Model doctor's appropriate facial expression for bright patients.

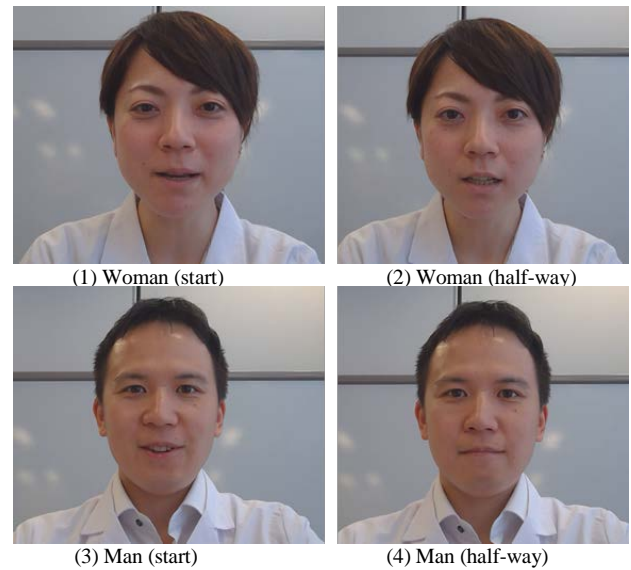


Figure 10. Model doctor's appropriate facial expression for expressionless patients.

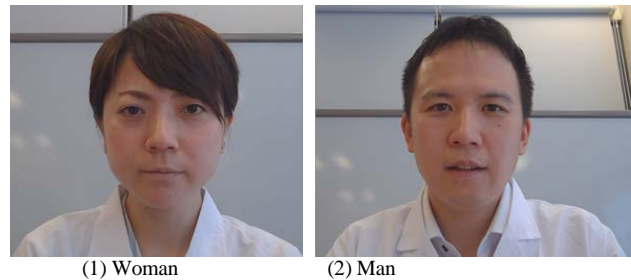


Figure 11. Model doctor's appropriate facial expression for patients in pain.

V. EVALUATION

A. Experiment

Six participants including three medical students played doctors and greeted patients with facial expressions that they thought appropriate for each condition of Figure 5. The application recorded them (before training), the participants repeated the facial-expressions training so that they could approximate the analysis results of the model doctors. After practice, we recorded their facial expressions again (after training). Although evaluation by actual patients is best, it would have been difficult to request actual patients' participation. Hence, we asked 30 general healthy adults

who had been hospitalized in the past or would be in the future. We showed the video recordings (before and after training) to 10 men and 20 women (average age 41.0 years) without sound. We asked them to judge whether the doctor’s facial expression was appropriate for the condition on a 3-point scale (1: appropriate, 2: neutral, 3: not appropriate). We asked them to also comment on anything they felt or noticed. We showed the recordings without sound because we wanted them to focus on the appropriate facial expressions in medical communication conditions, and emotion is easier to read from speech than from facial expressions.

B. Effects of Training

The graph of Figure 12–15 showing the result of the rating before and after the training is as follows.

In order to examine the effects of training with the application, we conducted 2 (using the application: before and after) × 6 (doctors) two-way analysis of variance with the evaluation results as the dependent under four conditions. The results showed a significant difference at the 1% level under all conditions (in order from condition 1, $F(59, 295) = 3.19, P < .01$; $F(59, 295) = 4.51, P < .01$; $F(59, 295) = 4.52, P < .01$; $F(59, 177) = 5.26, P < .01$).

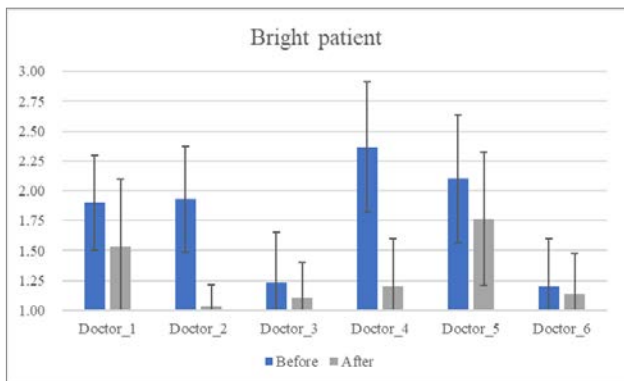


Figure 12. Average and standard deviation of each doctor’s evaluation score for bright patients.

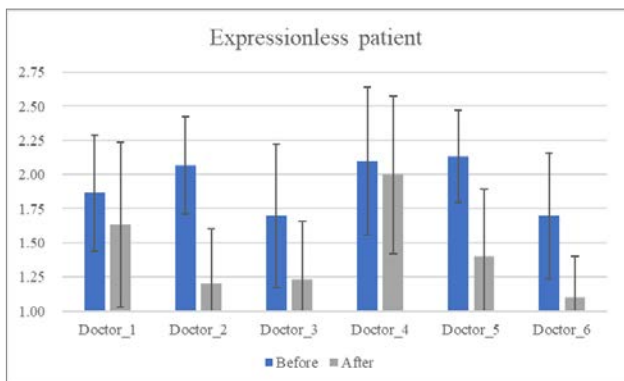


Figure 13. Average and standard deviation of each doctor’s evaluation score for expressionless patients.

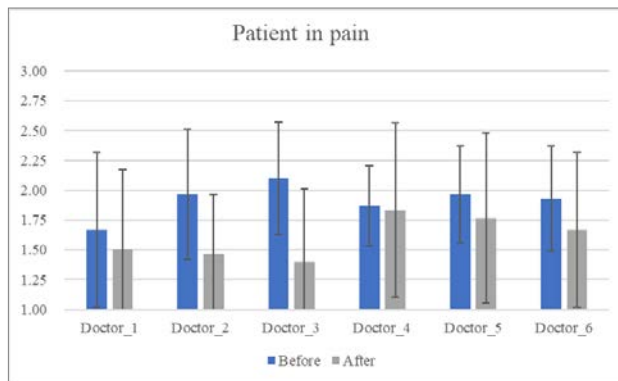


Figure 14. Average and standard deviation of each doctor’s evaluation score for patients in pain.

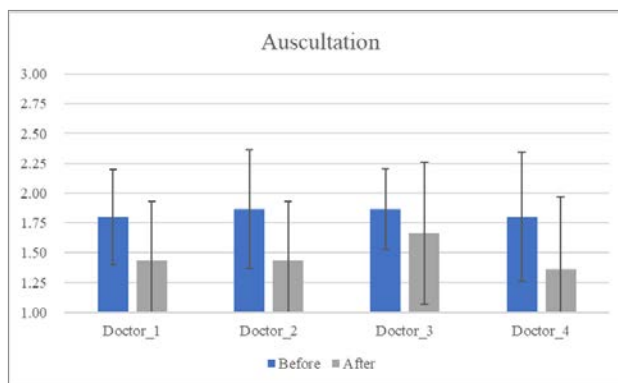


Figure 15. Average and standard deviation of each doctor’s evaluation score for auscultation.

We consider the effectiveness of this application to have been confirmed because the evaluation scores improved with use of the application under all conditions. We also noticed the following two points during the experiment. The first point is that the evaluation for “patients in pain” was different for each person. Most persons regarded the doctor’s serious expression as empathy and evaluated that as adequate. However, a few persons felt that the doctor’s expression caused unease and worry, and that person evaluated the expression as not adequate. Therefore, the model expressions for patients in pain may not be limited to one type. The second point is that the facial expressions practiced in the application are unnatural for a few persons. By training in the application, people playing the role of doctor created expressions close to those of the model doctor’s videos, and accordingly the evaluation score rose. However, when a facial expression that the participants learned was far from facial expressions that they always do, a few evaluators felt that the expression looked like “a pretended expression” or “artificial expression.”

VI. CONCLUSION

We developed a facial-expression training application that physicians can use for independent-study. Six participants practiced using this application to express appropriate facial expressions. To verify the effectiveness of

this application, the facial expressions that participants made before and after training with it were evaluated by 30 people. On the basis of the results, we consider the usefulness of the facial-expression training application to be verified. We think most learners could express their facial expression naturally by practicing repeatedly.

In the future, we will improve the application so that the on-screen instructions will guide the learner's expressions more properly. In addition, because requirements for a doctor who cares for children are very different from those of one who cares for adults, we plan to add learning content for pediatricians.

REFERENCES

- [1] A. Donabedian, *The Definition of Quality and Approaches to Its Assessment*. Ann Arbor, MI: Health Administration Press, 1980.
- [2] S. H. Kaplan, S. Greenfield, and W. E. Ware, Jr, "Assessing the effects of physician-patient interactions on the outcomes of chronic disease," *Med. Care*, vol. 27, pp. S110–S127, March 1989.
- [3] L. M. Noble, A. Kubacki, J. Martin, and M. Lloyd, "The effect of professional skills training on patient-centredness and confidence in communicating with patients," *Med. Educ.*, vol. 41, pp. 432–440, May 2007.
- [4] J. A. Hall, D. L. Roter, and N. R. Katz, "Meta-analysis of correlates of provider behavior in medical encounters," *Med. Care*, vol. 26, pp. 657–675, July 1988.
- [5] J. A. Hall, J. A. Harrigan, and R. Rosenthal, "Nonverbal behavior in clinician-patient interaction," *Appl. Prev. Psychol.*, vol. 4, pp. 21–37, Winter 1995.
- [6] L. M. Ong, J. C. de Haes, A. M. Hoos, and F. B. Lammes, "Doctor-patient communication: A review of the literature," *Soc. Sci. Med.*, vol. 40, pp. 903–918, April 1995.
- [7] T. L. Thompson, "Interpersonal communication and health care," in *Handbook of Interpersonal Communication*, 2nd ed., M. L. Knapp and G. R. Miller, Eds. Thousand Oaks, CA: Sage, pp. 696–725, 1994.
- [8] S. Williams, J. Weinman, J. and J. Dale, "Doctor-patient communication and patient satisfaction: A review," *Family Practice*, vol. 15, pp. 480–492, October 1998.
- [9] M. R. DiMatteo, A. Taranta, H. S. Friedman, and L. M. Prince, "Predicting patient satisfaction from physicians' nonverbal communication skills," *Med. Care*, vol. 18, pp. 376–387, April 1980.
- [10] M. R. DiMatteo, R. D. Hays, and L. M. Prince, "Relationship of physicians' nonverbal communication skill to patient satisfaction, appointment noncompliance, and physician workload," *Health Psychol.*, vol. 5, pp. 581–594, 1986.
- [11] A. Oe and Y. Murata, "Quantitative Analysis of Facial Expression for Medical Doctors," IARIA, proceeding of Global Health 2018, pp.8–13, 2018.
- [12] J. Bird, S. A. and Cohen-Cole, "The three-function model of the medical interview. An educational device," *Advances in Psychosomatic Medicine.*, vol. 20, pp. 65–88, 1990.
- [13] H. de Haes and J. Bensing, "Endpoints in medical communication research, proposing a framework of functions and outcomes," *Patient Educ. Couns.*, vol. 74, pp. 287–294, March 2009.
- [14] Z. Ben-Sira, "Affective and instrumental components in the physician-patient relationship: An additional dimension of interaction theory," *J. Health Soc. Behav.*, vol. 21, pp. 170–180, June 1980.
- [15] M. K. Buller and D. B. Buller, "Physicians' communication style and patient satisfaction," *J. Health Soc. Behav.*, vol. 28, pp. 375–388, December 1987.
- [16] B. M. Korsch and V. F. Negrete, "Doctor-patient communication," In *Physician-patient Communication: Readings and Recommendations*, G. Henderson, Ed. Springfield, IL: Charles C. Thomas, pp. 29–40, 1981.
- [17] S. J. Williams and M. Calnan, "Convergence and divergence: Assessing criteria of consumer satisfaction across general practice, dental and hospital care settings," *Soc. Sci. Med.*, vol. 33, pp. 707–716, 1991.
- [18] R. C. Wasserman, T. S. Inui, R. D. Barriatua, W. B. Carter, and P. Lippincott, "Pediatric clinicians' support for parents makes a difference: An outcome-based analysis of clinician-parent interaction," *Pediatrics*, vol. 74, pp. 1047–1053, December 1984.
- [19] R. C. Wasserman, T. S. Inui, R. D. Barriatua, W. B. Carter, and P. Lippincott, "Pediatric clinicians' support for parents makes a difference: An outcome-based analysis of clinician-parent interaction," *Pediatrics*, vol. 74, pp. 1047–1053, December 1984.
- [20] H. S. Friedman, M. R. DiMatteo, and A. Taranta, "A study of the relationship between individual differences in nonverbal expressiveness and factors of personality and social interaction," *J. Res. Pers.*, vol. 14, pp. 351–364, September 1980.
- [21] L. A. Camras, and M. M. Shuster, "Current emotion research in developmental psychology," *Emotion review*, 5, pp. 321–329, 2013.
- [22] M. Lewis, M. W. Sullivan, and A. Vasen, "Making faces: Age and emotion differences in the posing of emotional expression," *Developmental Psychology*, 23, pp. 690–697, 1987.
- [23] N. Takahashi and I. Daibo, "The facial expressions by emotion-instruction and photograph-instruction, and the effect of presence of another person in the facial expressions of anger and sadness," *Japanese Journal of Interpersonal and Social Psychology*, 3, pp. 65–72, 2003.
- [24] F. Kameyama and Y. Muraoka, "An Interactive Design System of an attractive smile," J IEICE technical report. Human information processing, 95(554), pp. 15–22, 1996.
- [25] Microsoft Emotion API, <https://azure.microsoft.com/en-us/services/cognitive-services/emotion/>, [retrieved: January 2019].
- [26] Open CV, <https://opencv.org/>, [retrieved: January 2019].