The evaluation of affection in human–robot interaction

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Abstract

Purpose – The purpose of this paper is to propose a novel method for evaluation of human-robot affection. The model is inspired by the scientific methods of human-human love evaluation. This paper would benefit the researchers in the field of developing new technologies where emotional interaction is involved.

Design/methodology/approach – Among the two available options of Functional Magnetic Resonance Imaging (fMRI) and user study, the latter is adopted and the conventional method of Love Attitude Scale is transformed for human-robot interaction as Lovotics (love + robotics) Love Attitude Scale. A user study is conducted to evaluate the emotional effect of interaction with the robot.

Findings – The proposed method is employed in order to evaluate the performance of Lovotics robot. In total, 20 users experienced interaction with Lovotics robot and answered questionnaires which were designed based on the psychology of love, especially to measure love scales between the participants and the robot. Data from the user study are analyzed statistically to evaluate the overall performance of the designed robot.

Research limitations/implications – Various aspects including human to robot love styles, robot to human love styles, overall love values and gender study are investigated during the data analysis. The concept of human-robot affection is still in initial stage of development. Personal and social robots are increasing and much limitation from artificial intelligence, mechanical development and integration still exist.

Practical implications – This is a multidisciplinary research field utilizing fundamentals concepts from robotics, artificial intelligence, philosophy, psychology, biology, anthropology, neuroscience, social science, computer science and engineering.

Social implications – Considering the recent technical advancement in robotics which is brining robots closer to home, this paper aims to bridge the gap between human and robot affection measurement. The final goal is to introduce robots to the society which are useful and can be especially used to take care of those in need such as elderly.

Originality/value – This paper is one of the first kind to get inspired from scientific human love evaluation methods and apply that to human-robot application.

Keywords Cybernetics, Robotics, Intelligent agents

Paper type Research paper

1. Introduction

Lovotics (Samani, 2012) is a research domain for developing a love relationship between humans and robots by utilizing fundamental concepts from psychology, biology, neuroscience and robotics. The primary requirement of Lovotics research is to develop a model that effectively imitates human affection process to create an emotionally engaging robotic system with high level of intimacy. Based on the previous Lovotics researches and studies, a Lovotics robot was developed with the ability to possess intimacy and reflect the feelings of love. The robot was designed and developed using several design theories for the hardware and various novel algorithms for the software. The artificial intelligence of the robot employs probabilistic mathematical models for the formulation of love. An artificial endocrine system was added in the robot by imitating human endocrine functionalities. Thus, the robot has the capability of experiencing complex and human-like biological and emotional states

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as governed by the artificial hormones within its system. The robot goes through various affective states during the interaction with the user. It also builds a database of interacting users and keeps the record of the previous interactions and degree of love.

The novel advanced artificial intelligence system of Lovotics includes an artificial endocrine system (based on physiology of love), Probabilistic Love Assembly (based on psychology of love) and affective state transition (based on emotions) modules.

Psychological unit of the Lovotics artificial intelligence calculates probabilistic parameters of love between humans and the robot. Various parameters such as proximity, propinquity, repeated exposure, similarity, desirability, attachment, reciprocal liking, satisfaction, privacy, chronemics, attraction, form and mirroring are taken into consideration.

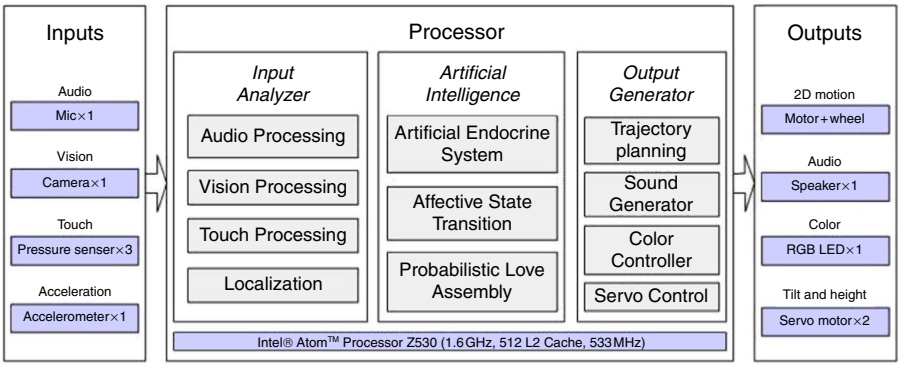
Physiological unit of the Lovotics artificial intelligence employs artificial endocrine system consisting of artificial emotional and biological hormones. Artificial emotional hormones include Dopamine, Serotonin, Endorphin and Oxytocin. For biological hormones Melatonin, Norepinephrine, Epinephrine, Orexin, Ghrelin and Leptin hormones are employed which modulate biological parameters such as blood glucose, body temperature and appetite.

A wealth of information about a person's emotions and state of mind can be drawn from facial expressions, voice, gesture, etc. The affective system of the robot analyses system inputs to generate suitable states and behaviors for the robot in real-time. The affective system is modeled as closely to the human being as possible in order to be an emotionally engaging system.

Different modules of Lovotics have been described in details including artificial intelligence (Samani and Saadatian, 2012; Samani and Cheok, 2010; Samani *et al.*, 2010), sensors (Samani *et al.*, 2011a; Ge *et al.*, 2008) and design (Samani *et al.*, 2011b). The videos of the robot during interaction are available online in Lovotics website[1]. The developed robot is presented in Figure 1 and developed system structure is illustrated in Figure 2.

The aim of this system is to pave the way to create personal relationships between humans and robots in the form of Lovotics to exhibit love between human and robotics. Definition of love between humans and robots can be analogous with the one between humans. With the purpose of defining love for Lovotics, the most prominent manifestations of love within philosophy, literature and psychology are investigated to find the element of resemblance in order to map that to a human-robot love definition.

Figure 1.
Lovotics robot



Note: Dark color boxes indicate hardware and light color boxes indicate software

Figure 2.
The overall structure of Lovotics robot which was developed in the research

The concept of love is extremely mysterious and enigmatic but at the same time it is highly inebriating and intoxicating. Various proposed interpretations of love generally have the contingent nature which causes several debates and critics for any suggested elucidation.

Throughout history there are several cases that looked at the structure of the love as a process. Details of defining love for human-robot interaction is presented in Lovotics book (Samani, 2012).

To evaluate the efficiency of the system including hardware, software and especially the developed artificial intelligence algorithms, a user study was conducted. For this study, the robot interacted with 20 users distinctly based on the designed evaluation method.

There are many different evaluation methods; which to use depends on the goals of the evaluation. Evaluations can occur in a range of places such as laboratories, people's homes, outdoors and work settings. Evaluations usually involve observing participants and measuring their performance in usability testing, experiments or field studies. There are other methods, however, that do not involve participants, such as modeling user behavior. These tend to be approximations of what users might do when interacting with an interface, often done as a quick and cheap way of assessing different interface configurations. The level of control on what is evaluated varies; sometimes there is none, such as in field studies, and in others there is considerable control over which tasks are performed and the context, such as in experiments (Sharp *et al.*, 2007; Rubin and Chisnell, 2008). The conventional method of evaluating a system consists of evaluation of modules separately whereas the adopted method of evaluation through user study of the entire system provides a general feedback about overall progress of the robot (Shedroff, 2001; Yanco *et al.*, 2004).

Prior to this, numerous researches have proposed methods to measure the extent of love and love style in human interpersonal relationships. The previous studies provide the information about how the love among two entities should be evaluated and how the extracted information can be used to find the developed love style. As no prior research has been done for measuring love in human-robot interaction, the studies on human interpersonal relationships were adapted with some transformation to make them suitable for human-robot interaction. The method of user study was adopted to measure love in human-robot interaction. In order to perform an effective evaluation, the psychology of love in human interpersonal relationships was studied and was

carefully replicated for human-robot interaction and a set of relevant questions was formed. The questions were designed to extract the information about the feelings and extent of love established in the interaction.

The obtained results of evaluation show how various parameters influence the feeling of intimacy, hence providing the required information for developing new generation of Lovotics robot with higher degree of bi-directional love. The study also provides the information about the relevance and irrelevance of any robotic feature in the development of bi-directional love during interaction. The adopted method opens a new research scope for enthusiasts of human-robot interaction. The gender-based analysis of the results would help in studying the psychology of males and females toward robots, thus providing useful information about the features which make a robot "attractive for males" and "attractive for females". Similarly, the features which make a robot "attracted toward males" and "attracted toward females" can also be found.

The main contributions of this paper are as follows:

- methods for measurement of love in humans are investigated;
- based on the common methods of human love measurement, a novel method for measurement of human-robot love is proposed;
- a user study is conducted in order to evaluate the Lovotics robot; and
- data of the user study is analyzed to investigate the capabilities of Lovotics.

In Section 2, background work for love measurement is investigated. A novel method for measuring human-robot love is proposed in Section 3 and results are presented and discussed in Section 4. This paper is concluded in Section 5.

2. Background

Love is considered to be a complex neurological phenomenon, relying on trust, belief, pleasure and reward activities within the brain, which is, limbic processes (Esch and Stefano, 2005). In science, love appears to be a hypothetical and multi-dimensional construct with many interpretations and implications, and often involves the context in which it is defined. However, early phases of love, such as falling in love can be directly evaluated by studying the neurobiology and user experience (Esch and Stefano, 2005; Zeki, 2007).

Functional Magnetic Resonance Imaging (fMRI) by studying the neural activity of brain and user study by analyzing the love through a self-report questionnaire are two general scientific methods of human love measurement.

fMRI uses the intrinsic magnetic properties of a substance to produce images of internal anatomical structures such as the brain. By taking a rapid series of functional images, it is possible to infer which regions of the brain are more active during certain tasks like interpersonal processes. Several recent cognitive neuroscience studies have examined the brain's involvement in interpersonal processes and development of love (Zeki, 2007; Marazziti, 2005; Gunther *et al.*, 2009).

User study is a procedure of asking the user about their experience regarding any new technology, innovation or ideas they have put across. Surveys and structured interviews are two types of extensive research methods which are generally used for performing user studies. These methods have been used by many researchers to evaluate human love (Masuda, 2003; Hendrick *et al.*, 1998; Hendrick and Hendrick, 1989).

The evaluation of love through user study can be classified into various love scales (Masuda, 2003). These love scales are used for determining different love aspects of a relationship.

The most commonly used love scales are Passionate Love Scale (PLS), Sternberg's Triangular Love Scale (STLS), Lasswell's Love Scale and Love Attitude Scale (LAS). PLS analyzes the intensity of love as romantic love, infatuation, love sickness or obsessive love (Hatfield and Sprecher, 1986; Hatfield *et al.*, 1988); similarly, STLS is used for determining the intimacy, passion and commitment factors of a relationship (Sternberg, 1986, 1997) and Lasswell's Love Scale includes parameters including love, liking, Storge and Agape (Lasswell and Lasswell, 1976).

The LAS uses Lee's (1973, 1976) "colors of love" theory to determine the love style of a person. Many researchers, including Hendrick (Hendrick *et al.*, 1998; Hendrick and Hendrick, 1989) and Richardson *et al.* (1988) have used this method for analyzing and evaluating human love. This method has been widely researched; hence, it has been adapted and transformed as Lovotics Love Attitude Scale (LLAS) for the evaluation of human-robot love. By using LAS, the love style of a person toward another person, often referred as "colors of love" is identified. Similarly, by using LLAS, the love style of a person toward a robot can be identified. A summary of the love measurement methods is presented in Table I.

The researches by Lee (1973, 1976) and Hendrick (Hendrick *et al.*, 1998; Hendrick and Hendrick, 1989) show how the six "love styles" are used by people in their interpersonal relationship. These love styles are considered to be the models of how people love and are briefly explained as follows:

- Eros – sentimental and intuitive physical attraction. It mostly refers to stereotype of romantic love and it s a sensual style of love. It can also refers to love at first sight. Erotic lovers choose their lovers by intuition or chemistry.
- Ludus – enjoyment of the fun of playing. It is mostly about quantity than quality of relationship. Ludic lovers choose their partners by playing the field, and quickly recover from break ups.
- Storge – affection that slowly develops from companionship. Storgic love develops gradually out of friendship, and the friendship can endure beyond the breakup of the relationship. Storgic lovers place much importance on commitment.
- Pragma – finding desired attributes rationally. Pragmatic lovers think rationally and realistically about their expectations in a partner and want to find value in their partners.

Evaluation of love	
Human-human love	Human-robot love
Functional MRI (fMRI)	
User study (self-report)	User study (self-report)
Neural activity study	
Sternberg's Triangular Love Scale	Lovotics Love Attitude Scale (LLAS)
Passionate Love Scale	
Lasswell's Love Scale	
Love Attitude Scale (LAS)	

Table I.
Love measurement methods

- Mania – volatile and obsessive need. Manic lovers often have low self-esteem, and place much importance on their relationship.
- Agape – selfless altruistic and sacrificial devotion. Agapic lovers view their partners as blessings, and wish to take care of them.

3. Methodology

The LLAS is an adaptation of LAS from human-human love to human-robot love. The key issues of LAS which decide the love style of human were studied and were mapped to the Lovotics aspect for developing a similar love response for human-robot love. The LLAS also gives us the love style of a person similar to LAS, but with respect to human-robot love. The six "colors of love" or "love styles" as proposed by John Lee (1976, 1973), then continuously researched by Hendrick *et al.* (1998) are mapped from human-human love to human-robot love for Lovotics. Results are shown in Table II.

Human-robot love for Lovotics is proposed to be considered as three different cases: Human-to-robot love (human→robot), robot-to-human love (robot→human) and bi-directional human-robot love (human↔robot).

During the study, the users are requested to interact with the robot. They are then asked to answer a questionnaire based on their interaction with the robot. The questionnaire for LLAS is adapted from short form of LAS and presented in Table III.

To implement LLAS for evaluating the two main parameters (human to robot love (human→robot) and robot to human love (robot→human)), the users are asked to answer 48 questions (two parameters × six styles × four items), using the response that indicated how much they agree or disagree with that statement: 1, Strongly Disagree; 2, Moderately Disagree; 3, Neutral – neither Agree or Disagree; 4, Moderately Agree; and 5, Strongly Agree.

Based on the user responses the mean value of all six love styles are measured, for both human to robot love and robot to human love in scale of 0-1. The mapping of these two ranges is presented in Table IV. Human-robot love (human↔robot) can be calculated using human→robot and robot→human.

A novel method of evaluating the love in human-robot interaction is proposed by using previous studies of psychology of love and the love styles expressed and experienced by humans. To evaluate the extent and type of love developed in human-robot interaction, ten males and ten females were selected to interact with robot for two hours each. Participants of the user study were mostly in the age range of 20-35 years old. Most of participants were familiar with technology and robots in general however selected participants for the user study were not involved in Lovotics project development.

Table II. Love styles for Lovotics

Love style	Definition	Key issue	Lovotics aspect
Eros	Sentimental and intuitive physical attraction	Physical	Aesthetic
Ludus	Enjoyment of the fun of playing	Fun	Behaviors
Storge	Affection that slowly develops from companionship	Friendship	Interaction
Pragma	Finding desired attributes rationally	Logic	Artificial intelligence
Mania	Volatile and obsessive need	Need	Ownership
Agape	Selfless altruistic and sacrificial devotion	Care giving	Nurture

Sl. no.	Lovotics Human to Robot Love Attitude Scale	Lovotics Robot to Human Love Attitude Scale
Eros		
1.	I feel that I have chemistry with the robot	I feel that the robot has chemistry with me
2.	I was attracted to the robot immediately after I first met the robot	The robot was attracted to me immediately after first met me
3.	I was emotionally involved with the robot rather quickly	The robot was emotionally involved with me rather quickly
4.	The robot fits my standards of physical beauty	The robot seems to like my appearance
Ludus		
5.	What I don't know about the robot won't hurt me	What the robot doesn't know about me won't hurt it
6.	I could get over my affair with the robot pretty easily and quickly	The robot could get over its affair with me pretty easily and quickly
7.	I would get upset if I knew of some of the things robot have done with other people	I think that the robot would get upset if it knew of some of the things I've done with other people
8.	When the robot gets too dependent on me, I want to back off a little	When I get too dependent on robot, it backs off a little
Storge		
9.	My love towards the robot grew out of a long friendship	The robot's love towards me grew out of a long friendship
10.	I like the robot	The robot likes me
11.	The robot is my friend	I know myself as a friend of the robot
12.	I care about the robot	The robot cares about me
Pragma		
13.	The reason that I am attracted to this robot is that the robot is useful for me	The reason that the robot is attracted to me is that I am useful for it
14.	Logically I think that the robot is lovable	The robot loves me because of its artificial intelligence
15.	I see my desired parameters of a good partner in this robot	The robot finds its desired parameters of a good partner in me
16.	I love this robot by my head instead of heart	The robot loves me because of its computer programmes
Mania		
17.	When the robot doesn't pay attention to me, I feel sick all over	When I don't pay attention to the robot, it will get crazy
18.	Since I've been in love with this robot I've had trouble concentrating on anything else	The robot is so in love with me that it cannot do anything else
19.	I cannot relax if I suspect that my robot is with someone else	The robot cannot relax if it suspects that I am with someone else
20.	If the robot ignores me for a while, I sometimes do stupid things to try to get its attention back	If I ignore the robot for a while, it sometimes do stupid things to try to get my attention back
Agape		
21.	I would rather suffer myself than let the robot suffer	The robot rather suffer itself than let me suffer
22.	I cannot be happy unless I place the robot's happiness before my own	The robot cannot be happy unless it places my happiness before its own
23.	I am usually willing to sacrifice my own wishes to let the robot achieve its	The robot is usually willing to sacrifice its own wishes to let me achieve mine
24.	I would endure all things for the sake of this robot	The robot would endure all things for the sake of me

Source: Adapted from short Love Attitude Scale (LAS) from human-human to human-robot

Table III.
Lovotics Love Attitude Scale (LLAS)

A brief introduction about Lovotics and the idea of human-robot love was presented, followed by a demo to show the features of the robot. The study was conduced for a span of five days and the user interactions were noted. Each user interacted with the robot for two hours at a rate of four human-robot interactions per day, hence completing 20 user interactions in five days. Using the samples of two hours interaction for every user, love scales were calculated and presented in the form of graphs. The open interaction showed various levels of involvement between the robot and the users. After each session, the users were asked to fill a questionnaire, which was designed to evaluate the developed love style. The widely accepted LAS was chosen and modified for human-robot love, in the form of LLAS. After completing the questionnaire, the users were asked to review the robot and quote its most attractive and repulsive feature. The gathered information will be used for making further improvements on the robot.

LLAS is our proposed method for measurement of affection during human-robot interaction. It is certainly required to discuss about the validity of this evaluation method. Validation and evaluation, even though different from each other, are very much linked (Marwedel, 2011). Specification, hardware platforms and system software provide us with the basic ingredients which we need for designing embedded systems. During the design process, we must validate and evaluate designs rather frequently.

Research Methods Knowledge Base (Trochim and Donnelly, 2001) provides a succinct and useful summary of each of the kinds of validity. Generally speaking, validity refers to whether or not a study is well designed and provides results that are appropriate to generalize to the population of interest.

It is possible to perform common verification methods for justification of the validity of the proposed LLAS, however we believe that proposed method followed standard usability testing guidelines for human-computer interaction (Gaines *et al.*, 2015) and by trusting the standard method our proposed method would be most likely as well. Certainly the proposed method has limitations. For example, because the questions are so specific to what the researchers are asking, the information gained can be minimal (Kaplan and Saccuzzo, 2012). Another concern with questionnaires is that there may contain quite large measurement errors (Alwin, 2007).

4. Results and discussion

The results of study on 20 users (ten males and ten females) about their interaction with the Lovotics robot are used to analyze the level of bi-directional human-robot love by considering the impact of gender.

For human to robot love (human→robot), the mean values of all six love styles are calculated based on the user responses regarding their feeling about the interaction process; whereas for robot to human love (robot→human) those values are calculated based on the user responses on Lovotics robot's point of view regarding the interaction process.

Table IV. Love scales for the LLAS

User's response	Love scale
Strongly Disagree	0
Moderately Disagree	0.25
Neutral	0.50
Moderately Agree	0.75
Strongly Agree	1

These values for human to robot love and robot to human love are calculated separately for both males and females and the results are presented in Figures 3 and 4, respectively. Mean values of love styles are between 0 and 1. In total, 95 percent confidence interval is illustrated by error bars.

4.1 Human→robot love

From Figure 3, it can be seen that the love styles Eros, Ludus, Storge and Pragma have mean values higher than 0.5 (for both males and females) whereas the love styles Mania and Agape have mean values less than 0.5 (for males). This reveals that the users were positively attracted toward robot's appearance, behavior, interaction and artificial intelligence; but they had less interest in owning the robot and taking care of it. Figure 3 also shows that females were more attracted toward the robot compared to males as females have higher mean values of all six love styles for human to robot love than males.

4.2 Robot→human love

According to Figure 4, it can be seen that in robot to human love the love styles Eros, Ludus, Storge and Pragma have higher mean values than the love styles Mania and Agape, similar to human to robot love(for both males and females). From Figure 4,

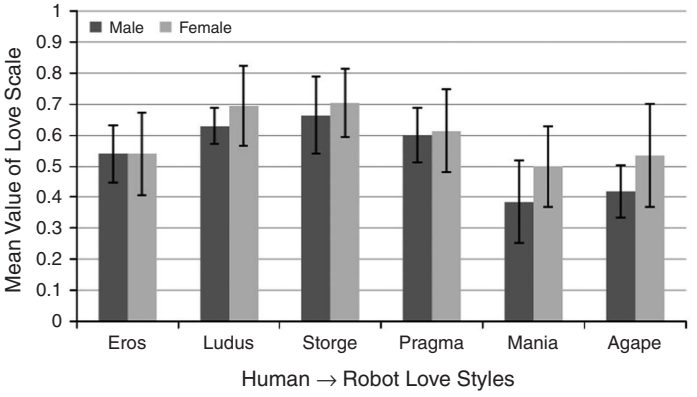


Figure 3.
Human-robot love, measurement of various love styles from humans toward the robot

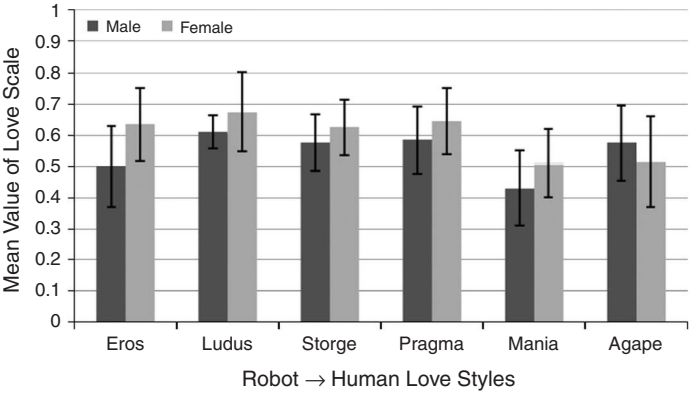


Figure 4.
Robot-human love, measurement of various love styles by the robot, experienced by users

it is also evident that females found the Lovotics robot was highly attracted toward them than males with respect to all love styles except Agape; whereas men felt more sacrificial and nurture responses by the robot. In coherence with the Figure 3, it was found that the robot to human love was more recognizable by females as compared to males.

4.3 Human↔robot love

To develop a better understanding of the human-robot bi-directional love and the impact of gender, data of Figures 3 and 4 were merged together to calculate aggregate love. The result is presented in Figure 5. Figure 5 illustrates that female users felt more love than male users during the interaction process as they have mean values of greater than or equal to 0.5, in scale of 0 to 1, for all love styles. This supported our previous observation that females are more interested in the human-robot bi-directional love than males.

Mean values of human to robot love, robot to human love and human-robot bi-directional love are calculated by averaging each parameter's mean values of love styles and all the results are shown on the same graph as Figure 6. For both, males and females, it is also found that the mean values of human to robot love, robot to human love and human-robot bi-directional love are almost equal. This shows that the users felt matching love styles and amount of love by the robot, thus establishing a better compatibility and companionship.

In order to compare and analyze the impact of each love style in human to robot love and robot to human love, mean values for all love styles are calculated by averaging the

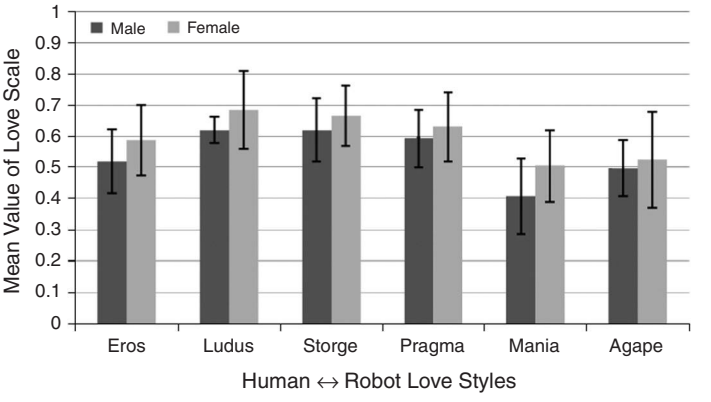


Figure 5.
Aggregate love, measurement of aggregate love styles developed in human-robot interaction

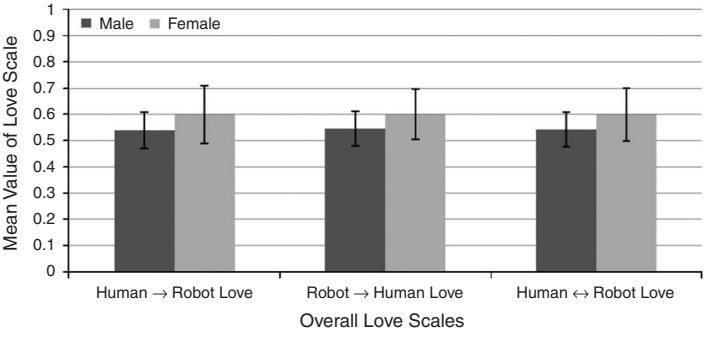


Figure 6.
Overall love, measurement of overall love developed in human→robot, robot→human, and human↔robot interaction

rates given by all users for respective styles and the results are presented in Figure 7. For the love styles Eros, Ludus, Pragma and Mania there is no significant difference in their mean values for both human to robot love and robot to human love. The mean value of Storge for human to robot love is higher than that for robot to human love. This reveals that the users are more keen in being friendly with the robot and develop that friendship. Whereas the mean value of Agape for human to robot love is less than that for robot to human love. It was also found that attraction between the users and the robot was mainly due to the appearance, behavior, interaction and intelligence whereas both did not experience high obsession and sacrificial devotion toward each other. This study shows coherence in the bi-directional love, developing better love compatibility.

We were also interested in examining if there is a relationship between the level of human to robot love and robot to human love and if a relationship was indeed found, also measure the strength of the relationship. We conducted Pearson correlation coefficient *t*-tests on the two variables (level of human to robot love and robot to human love) for all styles of love for examining the relationship between them. The Pearson correlation coefficient values are calculated separately for male users, female users and overall users; and the results are presented in Figure 8.

Overall Pearson correlation coefficient values of $r = 0.896$, $p < 0.001$ for male users; $r = 0.904$, $p < 0.001$ for female users and $r = 0.906$, $p < 0.001$ for overall users; suggest a strong positive relationship between the two variables namely the level of human to robot love and robot to human love. The coefficient of determination, ($r^2 > 0.75$) for all cases denotes the strength of the linear association between the variables independent of gender.

As it is shown in Figure 8, for overall users, the love styles Ludus, Storge, Pragma and Mania have higher Pearson correlation coefficient values ($r > 0.7$, $p < 0.001$) whereas the love styles Agape and Eros have slightly less values. For female participants all the love styles except Eros have higher r values. For male participants the love style Ludus has significantly much less r value, representing a very weak relationship between the two variables regarding this love style.

5. Conclusion and future work

A novel method for measuring human-robot love was proposed in this paper. This method was employed in order to evaluate the performance of Lovotics robot. Among the two available options of fMRI and user study, the latter is adopted and the

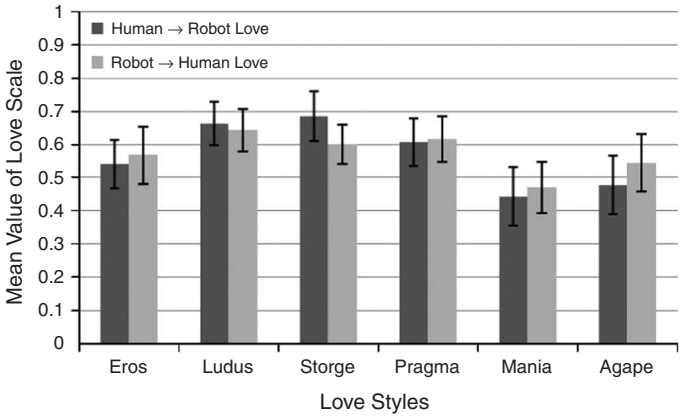


Figure 7.
Aggregate love, measurement of aggregate love styles developed in human→robot and robot→human interaction

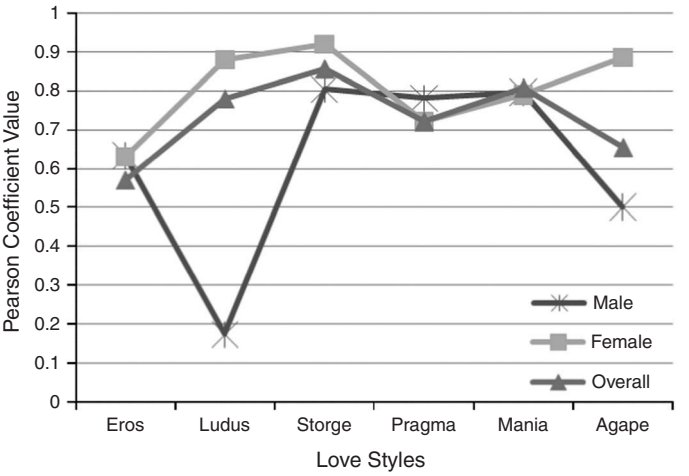


Figure 8.
Pearson correlation coefficient values of the two variables (level of human to robot love and robot to human love) for all styles of love

conventional method of LAS is transformed for human-robot interaction as LLAS. A user study was conducted to evaluate the emotional effect of interaction with the robot. Questionnaires were designed based on the psychology of love, especially to measure love scales between humans an the robot. Data from the user study were analyzed statistically to evaluate the overall performance of the designed robot. Various aspects including human to robot love styles, robot to human love styles, overall love values, and gender study were investigated during the data analysis. The user study showed some degrees of bi-directional love between Lovotics robot and humans.

While analyzing the graphs and gathered data, the following conclusions were drawn:

- Storge love style was the most dominant in terms of love from human toward robot for both sexes.
- The love from robot to human was mostly dominated by the Ludus love style irrespective of gender.
- The Ludus love style was most prominent in human-robot bi-directional love regardless of whether the person was male or female.
- Storge love style had the highest love scale value in human to robot directional love, and Ludus love scale value was the highest in robot to human directional love.
- Highest mean values for Ludus and Storge love styles indicates two aspects of graduate affection of companionship and enjoyment of playing with the robots.
- Mania love style has minimum values in the evaluation with the values below 0.5 that indicates negative response.
- The female love toward the robot dominated in unidirectional as well as bi-directional love between human and robots. It might refer to the design of the robot which was mostly found cute and adorable by female participants.

Lovotics introduces a novel interactive robots which focus inculcating intimacy with humans via a slow communication process. Through a long-term interaction with robot, interactants build up emotional attachment with the robot. This could create a

new form of bi-directional relationship between humans and robots. Lovotics introduces an interactive method which focuses on inculcating intimacy with humans. This holds potential for creating robots that can interact with humans at a level of emotional sophistication that is still lacking from robots today.

Users experience responses based not only on immediate inputs but also on prior interactions and relationships with particular humans. Constant close interaction with the robot can lead to a more intimate relationship. For example, if a new user strokes the robot, it may lead to a lower level of reciprocation when compared to similar action by a person familiar to the robot. Interactions are also influenced by parameters derived from the robots internal state.

Next step is to conduct an extensive qualitative fieldwork to help gather more data about user responses to the present developed robot and compare with other forms of robots. Using this information, it is possible to further redesign the robot to better evoke the sense of nurture and care within the robot and humans to further their love relationship.

As future work, the team is planning to do a longer user study, spanning for three to four weeks with more number of users. The development of Lovotics robot's appearance, from abstract form to humanoids is another big area for improvement. Using current abstract form of the Lovotics robot followed by the advanced form is another plan for future. Also it is planned to investigate the effect of social robots with Lovotics prospective.

It can be argued that adopting a working model of evaluation for human-human affection to human-robot model might not be enough. One of latest approaches in this regard is cognitive robotics method which could be employed to improve the proposed evaluation method. Cognitive robotics views animal cognition as a starting point for the development of robotic information processing, as opposed to more traditional artificial intelligence techniques. Target robotic cognitive capabilities include perception processing, attention allocation, anticipation, planning, complex motor coordination, reasoning about other agents and perhaps even about their own mental states. Robotic cognition embodies the behavior of intelligent agents in the physical world (or a virtual world, in the case of simulated cognitive robotics). Ultimately the robot must be able to act in the real world. While traditional cognitive modeling approaches have assumed symbolic coding schemes as a means for depicting the world, translating the world into these kinds of symbolic representations has proven to be problematic if not untenable. Perception and action and the notion of symbolic representation are therefore core issues to be addressed in cognitive robotics (Samani, 2015).

Along with the development of the robot itself, it was tried to understand and define the role of this new genre of robots in the social and cultural context. It is difficult to predict what the relationship will be between humans and robots in the future, and tough questions such as "how does this change our definition of love?" or "is this kind of love appropriate?" need to be addressed. The way to do this is to continue this study in exploring "love" and studying how man and machine are evolving into a new identity and relationship and to create a range of Lovotics robot to tackle these issues. Such issues could be studied as cultural robotics (Samani *et al.*, 2013; Saadatian *et al.*, 2013) where it could be investigated for the evolution of social to cultural robots for the twenty-first century. The potential development of a culture between humans and robots could be addressed. Based on the cultural values of the robots creators and learning ability of the robots, cultural attributes in this regard

are in the process of being formed which would define the new concept of cultural robotics. Sustainability of robotics culture based on diversity for cultural communities for various acceptance modalities could be explored in order to anticipate the creation of different attributes of culture between robots and humans in the future. In future social robots could be evaluated with the users of different culture and certainly it would be interesting to find out who people from different culture response to the same robot. Certainly such evaluation would be more creditable if evaluation is performed in long term were participants could interact with the robot for long period of time.

Note

1. www.lovotics.com

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