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Original Research Article

Wearable technology in emotive communication: An in-depth exploration of the kiss transfer mechanism and its implications for human-human interactions

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ABSTRACT

This paper delves deeply into the innovative realm of integrating human emotions with wearable technology. The primary focus is on the conceptualization and development of a kiss transfer device that harnesses the power of wearable technology to bridge the physical gap in human-human interactions. By investigating the intricate nuances of the human-human kissing process, the research seeks to replicate this intimate gesture through a technological medium. The paper not only elaborates on the anatomy, evolution, and hormonal dynamics of kissing but also underscores the transformative potential of wearable technology in capturing and transmitting these intimate moments. This exploration opens up new horizons for long-distance relationships, offering a tangible touchpoint that goes beyond traditional communication methods. Through this pioneering work, the research positions wearable technology as not just a tool for communication but as an extension of our human emotions and expressions.

Keywords: kiss transfer; wearable technology; human-human kissing; anatomy of kissing; evolution; hormonal changes; pheromones; long-distance relationships; kiss communicator; ComTouch

1. Introduction

The aim of this paper is to explore the related issues for developing a kiss transfer device using wearable technology. In this document, first, we investigate the general matters in the human-human kissing process and then explore different methods to develop a device in order to transfer the kiss.

1.1. Kiss description

A kiss is the touching of one person's lips to another place, which is used as an expression of affection, respect, greeting, farewell, good luck, romantic affection, or sexual desire.

1.2. Evolution

Anthropologists have not reached a consensus as to whether kissing is a learned or instinctive behavior. Kissing may lead to sexual behaviors. It may be related to grooming behavior also seen between other animals, or arising as a result of mothers premasticating food for their children.

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Kissing allows prospective mates to smell and taste each other's pheromones for biological compatibility. Women are subconsciously more attracted to men whose major histocompatibility complex portion of their genome is different from their own, leading to offspring with resistance to a greater number of diseases due to heterosis, and thus having a better chance of survival.

Non-human primates also exhibit kissing behavior. Dogs, cats, birds and other animals display licking and grooming behavior among themselves, but also towards humans or other species. This is sometimes interpreted by observers as a type of kissing.

1.3. The anatomy of kissing

Kissing is a complex behavior that requires significant muscular coordination; a total of 34 facial muscles and 112 postural muscles are used during a kiss (**Figure 1**). The most important muscle involved is the orbicularis oris muscle, which is used to pucker the lips and is informally known as the kissing muscle. The tongue can also be an extremely important part of the kiss. Lips have many nerve endings, so they are sensitive to touch and bite.

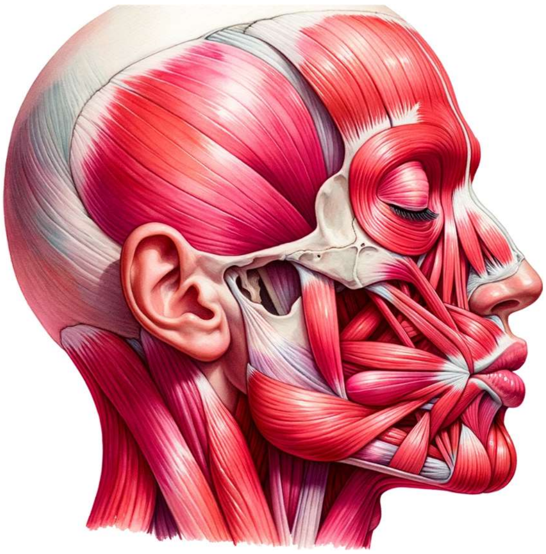

Figure 1. Related muscles involved in kissing.

1.4. Hormonal change through kissing

Two hormones, oxytocin and cortisol, are influenced by kissing. Cortisol levels, which usually rise when we're alert or stressed, drop when couples kiss, talk, or hold hands. Oddly enough, oxytocin levels increased for males after kissing but dropped in females. Oxytocin has been implicated in a number of social bonding activities, including orgasm and nursing an infant. Obviously, more research needs to happen in this area to see why men and women are reacting differently.

Another research shows that the following hormones are released during kissing:

- oxytocin, which helps people develop feelings of attachment, devotion, and affection for one another;
- dopamine, which plays a role in the brain's processing of emotions, pleasure and pain;
- serotonin, which affects a person's mood and feelings;
- adrenaline, which increases heart rate and plays a role in your body's fight-or-flight response.

1.5. The role of pheromones

Silent chemical messengers called pheromones could have sped the evolution of the intimate kiss. Many animals and plants use pheromones to communicate with other members of the same species. Insects, in particular, are known to emit pheromones to signal alarm, for example, the presence of a food trail, or sexual attraction.

Whether humans sense pheromones are controversial. Unlike rats and pigs, people are not known to have a specialized pheromone detector, or vomeronasal organ, between their nose and mouth. Nevertheless, biologist Sarah Woodley of Duquesne University suggests that we might be able to sense pheromones with our noses. Chemical communication could explain such curious findings as a tendency of the menstrual cycles of female dormitory mates to synchronize or the attraction of women to the scents of T-shirts worn by men whose immune systems are genetically compatible with theirs. Human pheromones could include a drostenol, a chemical component of male sweat that may boost sexual arousal in women, and female vaginal hormones called copulins that some researchers have found raise testosterone levels and increase sexual appetite in men.

If pheromones do play a role in human courtship and procreation, then kissing would be an extremely effective way to pass them from one person to another. The behavior may have evolved because it helps humans find a suitable mate—making love, or at least attraction, quite literally blind.

1.6. The reason of kissing

One idea about the reason of kissing is that human kissing evolved from a practice found in primate mothers, who may have pre-chewed food for their infants and then fed them mouth-to-mouth. Subsequently, pressing lips even without food may have provided a signal of comfort and love.

Some scientists believe that the fusing of lips evolved because it facilitates mate selection.

1.7. The role of the kiss in a relationship

Kisses can convey important information about the status and future of a relationship. At the extreme, a bad first kiss can abruptly curtail a couple’s future.

1.8. Kiss and love

To the extent that kissing is linked to love, the act may similarly boost brain chemicals associated with pleasure, euphoria, and a motivation to connect with a certain someone. In 2005, anthropologist Helen Fisher of Rutgers University and her colleagues reported scanning the brains of 17 individuals as they gazed at pictures of people with whom they were deeply in love. The researchers found an unusual flurry of activity in two brain regions that govern pleasure, motivation, and reward: the right ventral tegmental area and the right caudate nucleus. Addictive drugs such as cocaine similarly stimulate these reward centers, through the release of the neurotransmitter dopamine. Love, it seems, is a kind of drug for us humans[1].

2. Kiss transfer

A kiss triggers a cascade of neural messages and chemicals that transmit tactile sensations, sexual excitement, feelings of closeness, motivation, and even euphoria. The following points are some key considerations when implementing the technology for kiss transfer:

- Long-term relationship: couples in long distance require new devices in order to transfer the intimate feeling;
- technology adaption: new technologies require devices to satisfy natural human needs. new devices for better communication could be equipped with more facilities for better communication[2];
- improvement of the available communication tools;
- covering a wide range of long-distance relationships: parents-children, couples, friends ...;
- development of new tools for human-machine interaction;
- extending this tool from kiss transfer between human-human to human-machine;

- employing such devices to equip robots with new functionality.

The following disadvantages could be considered for using the kiss transfer tool between people:

- people don't prefer to have intermediate devices for kissing;
- people may not trust such devices for private affection;
- the device would increase the artificial and fake affection ratio of the intimate relationship;
- people require more communication (hug, touch, ...) during kissing to feel good enough.

The following topological design considerations should also be addressed:

- Are the devices dedicated to one other device?
- Is communication real-time stored or both?
- How sensitive should the input mechanism be?
- How accurate the output mechanism should be?
- What are the other communication media this should bind into?
- How complex the system should be?

2.1. Related work

Over the years, researchers have made efforts to delve into the realm of haptic communication, aiming to bridge the gap of physical touch in digital communication. While there were limited attempts in the early days, the concept has gained traction in recent times due to the increasing need for remote interpersonal communication. These endeavors have sought to recreate the tangible experience of touch, ranging from simple tactile sensations to more complex interactions like kissing[3,4].

2.1.1. Kiss communicator

Originating in 1999, the kiss communicator was a pioneering device in its time. Designed to communicate exclusively with a designated counterpart, its primary function was to transmit the sensation of a kiss. The device utilized a squeeze recognition input mechanism, likely a rudimentary button, which, when activated, initiated the sending of kisses. Based on the intensity and nature of the squeeze, a distinct light pattern would be produced. This pattern, representing the sent kiss, would then be conveyed to the paired communicator, allowing users to share a virtual kiss[5].

2.1.2. ComTouch

ComTouch represents a significant leap in haptic communication research. The device, rather than merely transmitting preset sensations, augments voice communication with the sense of touch. It achieves this by converting the pressure applied by a user's hand into varying vibrational intensities, which are then felt by the recipient in real time. This system aims to enrich dialogues by adding a tactile dimension to them. The researchers identified three primary applications for this technology: emphasizing certain parts of a conversation, mimicking or mirroring the other person's sentiments, and facilitating conversational turn-taking[6].

2.1.3. Poultry Internet and Internet pajama: Novel systems for remote haptic interaction

Branching out from the traditional domain of human-human interaction, this research delves into broader sensory engagements. Recognizing the multi-sensory nature of deep and emotional interpersonal communication, the paper emphasizes the importance of various senses like touch, color perception, warmth, and even scent. For a truly immersive experience, such as feeling a real and vivid kiss, it posits that all these sensory aspects must be met to a satisfactory degree[7].

2.2. An AR system for haptic communication

Acknowledging the limitations of contemporary communication systems that predominantly revolve around audio and video, this research introduces a novel approach to haptic communication over the Internet. It incorporates Augmented Reality (AR) to provide a more holistic and immersive touch experience. Given the ubiquity and potential of the internet, it's posited that it will play a pivotal role in the future of haptic communication, especially in intimate interactions like kissing[8].

2.3. Haptic wearables for remote interaction

In the era of wearable technology, haptic wearables have emerged as a promising avenue for remote touch communication. These wearables, often in the form of bracelets or garments, simulate touch sensations using actuators and sensors. They can recreate the warmth of a hug, the squeeze of a hand, or the peck of a kiss[9].

2.4. Virtual reality and haptic feedback

Virtual reality (VR) has shown immense potential in bridging the physical distance between individuals. When combined with haptic feedback systems, VR can recreate lifelike environments where users can not only see and hear each other but also touch. This combination paves the way for more intimate and realistic remote interactions, where gestures like holding hands or sharing a kiss can be experienced in a virtual space, closely resembling reality[10].

3. Mediating intimacy: Technological innovations for enhancing strong-tie relationships

This paper delves into the intricate dynamics of how interactive technologies can be employed to bolster intimate relationships. By employing a thematic analysis, we explore the nuances of intimacy and how interactive technologies can be designed to facilitate intimate interactions.

3.1. Proposed wearable kiss communication device: An in-depth technical overview

The kiss communicator, as conceptualized in this study, aims to revolutionize physical-level kiss communication. The device is designed to capture the unique characteristics of a kiss—such as lip shape and pressure—and transmit them to a paired device. In **Figure 2**, we present a comprehensive flow diagram that outlines the key technical considerations for this innovation.

3.2. Kiss input: Sensory technologies and material considerations

The device employs advanced sensory technologies to detect real physical kisses. The primary objective is to accurately capture the physical deformation caused by the lips on the initiating device and replicate it on the recipient device. For this, a soft, deformable pad embedded with multiple sensors is utilized.

3.3. LVDT (Linear Variable Differential Transformers): A micro-level analysis

VDTs are employed to capture the intricate patterns formed by the lips. These sensors generate a variable voltage based on the force exerted, allowing for a highly detailed capture of the kiss. The technology offers high accuracy and repeatability but poses challenges in terms of mounting multiple LVDTs on a single pad (**Figure 3**).

Once the pattern data is at hand it can be transported at will to devices that can replicate this formation.

Mature technology: Available in very small packaging that suits this kind of application.

High accuracy and good repeatability are other key features of this technology. However, the increased number of LVDTs used in pads makes it hard to mount.

For a more comprehensive understanding of LVDT technology, readers are referred to related information[11,12].

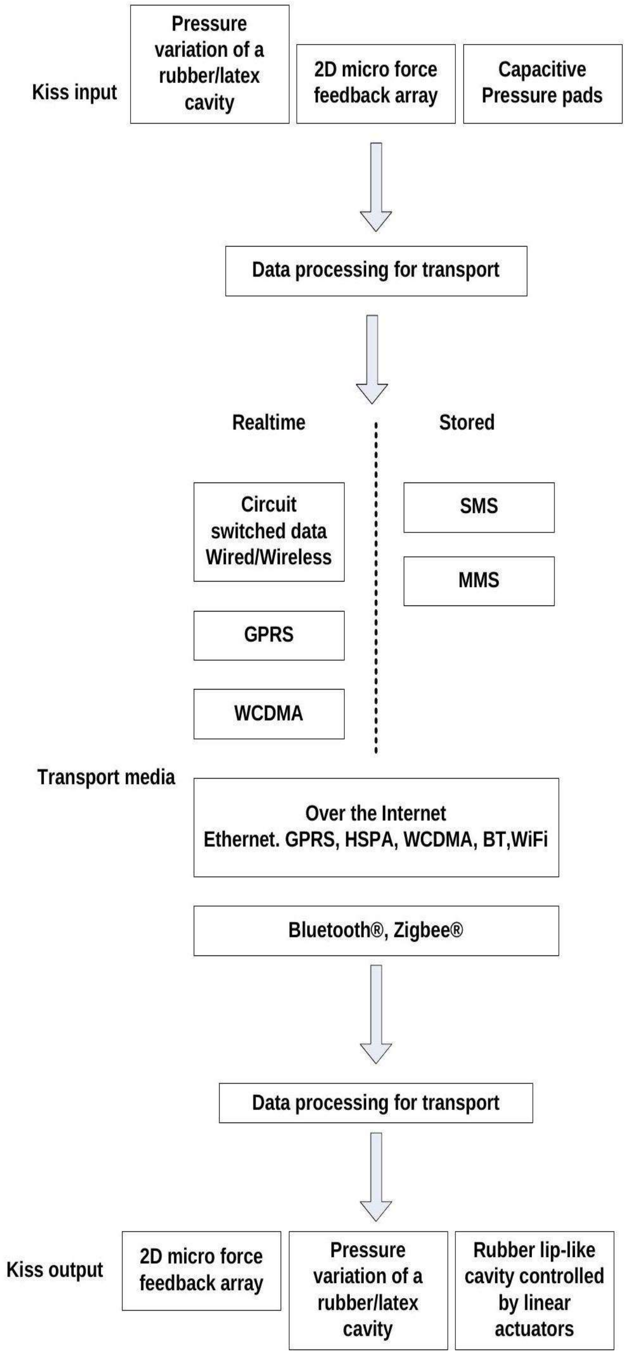

Figure 2. The flowchart of the proposed device.

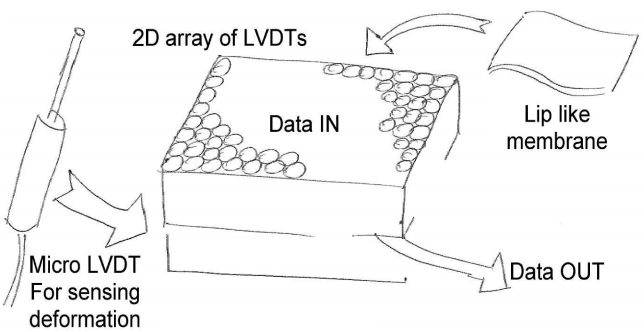

Figure 3. LVDT array in Lip pad.

3.4. Pressure sensing: An alternative approach

An alternative to LVDTs is the use of pressure sensors. These sensors measure the pressure change in an air cavity connected to a lip-like sensor (**Figure 4**). While this method is less complex and can function as both input and output, it compromises on accuracy and response time.

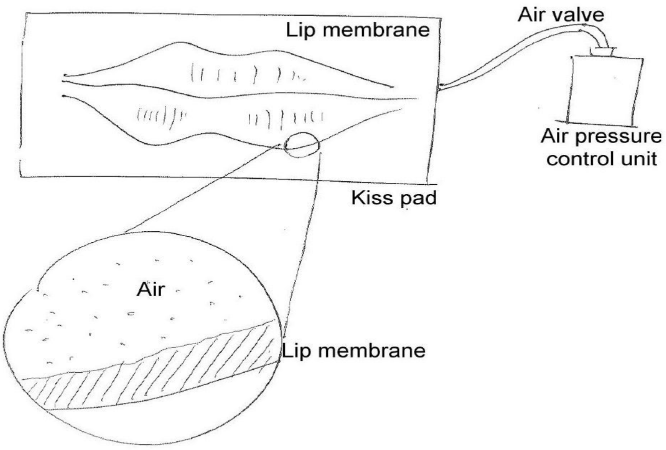

Figure 4. Lip-like cavity to measure pressure.

3.5. Comparative analysis of LVDT and pressure methods

A detailed comparison reveals that LVDTs offer higher accuracy but are complex to implement. On the other hand, pressure-based systems are easier to implement but lack the fine-grained detail provided by LVDTs. Custom modifications may be required for optimal performance.

Considering **Table 1**, it is clear that for more accurate mapping, spring-supported LVDTs are the choice though their implementation is difficult. As per the extensive search done suitable LVDTs are available without spring support. A custom modification or enhancement may be required before it can be used in this situation.

Table 1. Characteristics of LVDTs.

	LVDT	**Pressure**
Accuracy	Very accurate Has high resolution. Can be used with A2D function of microcontrollers to get fine results.	Not very accurate Pressure sensors are inherently having low resolution and slow to respond. This makes it less suitable for this kind of application.
Response time	Fast. Able to produce results with minimum delay.	Slow
As output	No	Yes When combined with an air pump, this can be used as an output device.
Size	Applicable Available in sizes as small as 2.3 mm diameter. This gives an acceptable accuracy for an application like this.	Applicable Can be modeled small. Then come the resolution issues leading to errors.
Complexity	Implementation is complex. Each to LVDT needs to be connected to a separate A2D channel. Thus only 10 of these can be integrated to a single microcontroller. Considering a pad that measures 50mmX30mm will consist of 240 LVDTs that requires at least 24 microcontrollers or 20 12channel A2D converters with 12 microcontrollers. With the delay associated with each A2D and local data communication overall sensor may be of low accuracy.	Not very complex Here, only the pressure in sensed. For that only a single chip circuit is sufficient.

4. Communication protocols: A detailed examination

We can consider two types of communication for our design as follows.

4.1. Real-time communication: Pros and cons

Real-time communication can be categorized into Circuit Switched Data, Internet-based, and short-range technologies like Bluetooth and Zigbee. Each has its own set of advantages and limitations in terms of reach, bandwidth, latency, and reliability.

Features of interest consist of high reliability, wide reach, and low latency. Bandwidth is not much of an issue since we are not planning to use a high data exchange. According to **Table 2**, circuit-switched data has the highest reach and lowest latency and emerges as the clear choice. But owing to the modern Internet technologies reliability it also can be used. It also has a wider reach and can be used directly without any modification or protocol design.

Table 2. Real-time kiss transfer.

	Circuit switched data	**Over the Internet**	**Bluetooth® and Zigbee®**
Reach	Can be wired or wireless. Reach is very high. For instance, GSM coverage is very strong in many parts of the world.	Last mile can be either wired or wireless. Less reach by developing parts of the world but very much penetrated in developed areas.	Pico nets. Can be used as the first mile of the communication over the Internet. On its own, forms a very small region of coverage within communication is possible at minimum trouble. Unlike Bluetooth, Zigbee has a greater area of coverage up to 60 km.
Bandwidth	Up to 14.4 kbps. Sufficient for this project.	Varies	Up to 1Mbps
Latency	Very low Uses dedicated lines. Therefore minimum delay when using reliable protocols.	Low Varies with the protocol used. If reliability to be ensured need to compromise some speed.	Very low
Reliability	High	Varies with the protocol	High
Availability	High	Varies with the location	Very small coverage area (private coverage area)

4.2. Stored media: An alternative approach

Stored media options like SMS, MMS, and Databases offer varying degrees of reach, data size, reliability, and availability. These technologies are mature and can be employed without modification, making them suitable for prototype development, as described in **Table 3**.

Table 3. Transferring the kiss through stored media.

	SMS	**MMS**	**Databases**
Reach	Greater coverage	Greater coverage	Limited coverage
Size (data)	Very limited In typical single message only 160 bytes and in concatenated messages up to 500 bytes.	Up to few kilobytes worth of data.	Greatest size. Even up to Mega byte scale.
Reliability	Very reliable	Reliable	Reliable Depend on the protocol being used.
Availability	High	Acceptable	Low (Pico networks)

In summary, both real-time and stored media have their merits and drawbacks. For initial prototypes, wired communication or GPRS can be employed, with the potential for scaling up to more advanced technologies in later stages.

5. Advanced kiss output mechanisms: A detailed structural and functional analysis

In the kiss communicator, the kiss output is traditionally represented by a series of light patterns on the receiving device. However, the objective of this study is to elevate this experience by achieving a near-accurate modeling of lip patterns on the receiving device. Below, we discuss several mechanisms to accomplish this, focusing on their structural and functional aspects.

5.1. Mechanical actuators: A comprehensive examination

Mechanical actuators typically convert rotary motion into linear motion (see **Figure 5**). The smallest commercially available actuator measures 6.5 mm in diameter, with a range of 20 mm and a speed of 8 mm/s. While these specifications are close to meeting our requirements, they are not sufficient for accurately modeling lip shapes due to the absence of encoding.

Even if an actuator of the desired size exists, this only can be used as an output. If linear actuators are to be used as an input some encoding mechanism should be there and the actuator needs to be a non-locking type. Due to physical dimension restriction no linear actuator that fulfills this entire set of requirements can be found so far.

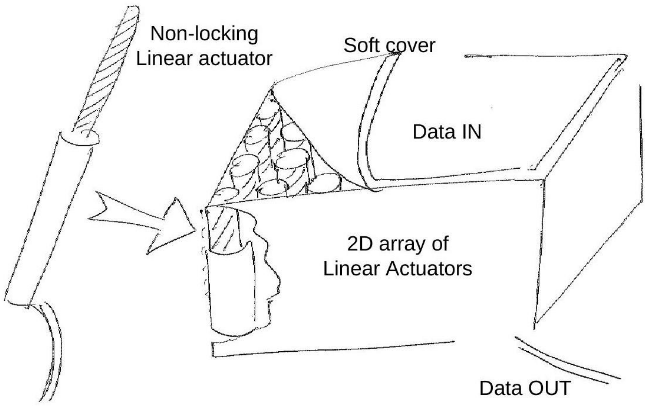

Figure 5. Linear actuators as an output.

Table 4. Comparison of linear actuator, pressure and solenoid.

	Linear actuator	Pressure	Solenoid
Accuracy	High Even though no encoders inbuilt good results can be achieved by time controlling.	Low If air is used, high compression ratio of air makes its accuracy very low. But with a liquid this limitation can be overcome.	Low Only has binary output. Therefore, a sensitive modeling like this cannot be done with solenoids.
Response time	Fast Has decent response time (8 mm/s). This is a critical factor in this user interface.	Slow Makes this technology not suitable for this kind of application.	Fast Response time is very fast.
As input	Yes (Non-locking and encoded) This is a very interesting point. Avoids the need of using separate systems for input and output.	Yes Avoids the need of using separate systems for input and output.	No
Size	Small Available in diameters of 6.5 mm. Yet this is not small enough.	Applicable Can be formed into any shape and size of interest. Very flexible.	Small Available in smaller sizes.
Complexity	High Motor driven. Therefore, motor driving mechanism need to be incorporated. Makes the system rather complicated.	Low Due to simple control of the system.	Medium
Resolution	High High resolution up to sub millimeter level. Ideal for sensitive applications.	Low medium Air: low Liquid: medium	Low Binary resolution.

According to **Table 4**, no output system performs to recreate a perfect kiss but approximations. Therefore, we propose some alternate ways to successfully approximate the kissing in a physical sense.

The apparatus consists of rubber or latex lips fitted with a few linear actuators to separate areas as shown in the figure. This intends to be used as the kiss output interface (**Figure 6**).

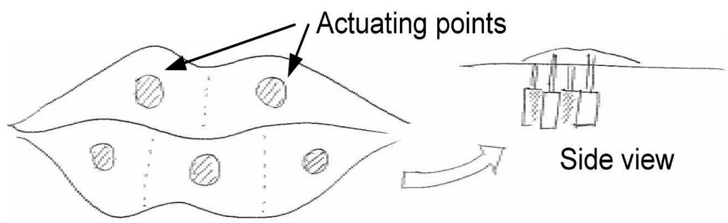

Figure 6. Rubber lip with actuators.

There are key benefits to this approach. It combines the linear actuator's speed and real lip shape approximation fairly well. The implementation also is not as complicated as in a total linear actuator system as only an admissible number of actuators are used.

Using this mechanism as an input is subject to research. Some preliminary ideas suggest mounting a pressure sensor on top of each actuator and detecting the pressure change once an input is given.

Warmth is another important quality of a kiss. To give a warm sensation, the output needs to be raised to the lip temperature of a typical human being. To achieve this, an accurately controllable heating system is required and at the moment this is subjected to further investigation.

5.1.1. Limitations and challenges

The size of the actuator limits the number of actuators that can be fitted into a given area, affecting the fidelity of the recreated kiss. Specifically, calculations show that only four actuators can fit per 169 mm^2. Additionally, the absence of encoding mechanisms limits the actuator's accuracy, although time control can partially mitigate this issue[12].

5.1.2. Proposed hybrid system: Rubber lip with actuators

To overcome these limitations, we propose a hybrid system that combines a rubber or latex lip structure fitted with a limited number of linear actuators.

This approach offers a balance between speed and accuracy, without overly complicating the system. Preliminary ideas for using this mechanism as an input include mounting pressure sensors on each actuator to detect pressure changes.

5.2. Thermal considerations: Adding the element of warmth

A kiss is not just about shape and pressure; warmth is an essential quality. To simulate this, an accurately controllable heating system is required. The integration of thermal elements into the output mechanism is currently under investigation.

5.3. Integrating kissing with other media: An untapped research area

Similar to ComTouch[6], which integrated touch with voice communication, the kiss communicator can be integrated with other widely-used communication media like voice and instant messaging. This integration could make these media more intimate and enhance the sense of presence between the involved parties.

6. Conclusion

In the rapidly evolving landscape of technological advancements, the research undertaken stands as a testament to the potential of wearable technology in bridging the emotional and physical divides inherent in human interactions. This paper has provided a comprehensive exploration into the multifaceted nature of the human-human kissing process, shedding light on its anatomy, evolutionary trajectory, and the intricate hormonal dynamics at play. By leveraging the capabilities of wearable technology, the research has pioneered a device that seeks to replicate and transfer one of humanity's most intimate gestures, the kiss. Such an endeavor not only underscores the transformative potential of wearable devices in enhancing human connections, especially in long-distance scenarios but also posits a future where technology and human emotions coalesce seamlessly. As we stand on the cusp of this intersection between human intimacy and technological innovation, it is imperative for future research to continue probing the ethical, social, and technological implications of such integrations. The research serves as a foundational step in this direction, heralding a future where technology amplifies, rather than diminishes, the depth and authenticity of human connections.

Author contributions

Conceptualization, EYZ and ADC; methodology, EYZ and ADC; formal analysis, EYZ and ADC; investigation, EYZ and ADC; writing—review and editing, EYZ, ADC, YY, JC, and ZP; supervision, ZP; project administration, ADC; funding acquisition, ADC. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare that they have no conflict of interest.

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