Short Paper

Study of Interest Change Model for TV-Watching Companion Robots Using Program Viewing History

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Summary We propose a method to generate and change the interests of a TV-watching robot based on the user's program viewing history. As a result of a simulation assuming that the robot and the user watched TV together for five years, we confirmed that the robot's interests were similar to those of the user, but had their own unique interests.

Keywords:communication robot, personality, words of interest, viewing history

1. Introduction

Watching television with multiple people is not only enjoyable from the program itself, but also has the effect of creating fun and new discoveries by encouraging people to communicate with each other, share emotions, and spend time together. However, the number of people in an average household in Japan is decreasing1) and the diversification of viewing styles due to the spread of various viewing devices such as smartphones2) means that opportunities for multiple people to watch television together are on the decline.

Therefore, we developed a communication robot that can watch TV together and speak and converse according to the content of the program, aiming to recreate the “living room viewing” style that matches the current viewing style. We are currently conducting research and development of a television viewing robot.3)

In order for a robot to spend a long time with the user in the home, just like a family member, it is important that the robot becomes attached to the user, for example by changing the content of the robot's speech and actions depending on the user. In this paper, we propose a method to generate the robot's interests from the viewing history of programs the robot has watched with the user and to continuously change them (interest change model), so that the user will become attached to the robot and will not get bored of communication with it. In this study, we conducted a simulation based on five years of user viewing data, assuming that a robot equipped with the proposed model and a user watched TV together, and confirmed the effectiveness of the proposed model.

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2. Giving TV-watching robots personality

Since watching television is a daily activity, it is necessary to consider ways to encourage people to use the robot continuously.
[4] clarified that forming a personality that becomes the robot's individuality through long-term communication with the user improves the impression and affection of the robot. In addition, Uchida et al. [5] demonstrated that a robot can grow by acquiring new keywords from the user's utterances, starting from a state of no knowledge like a child.
By doing so, we demonstrated that a wide range of users have impressions of the robot, such as "cute" and "friendly."

Based on these existing studies, we hypothesized that by giving a TV-watching robot different personalities (interests) for each user through TV viewing, attachment would be created, and that continually changing those personalities (interests) would lead to long-term use by users.

3. Proposal of a model for changing robot interests

3.1 Design of interest change model

In designing a model of interest changes for a TV-watching robot, We organized the requirements based on our hypotheses: 1) Robots have their own interests that are different from the user. 2) Their interests change depending on the programs watched together with the user. 3) The robot's interests are influenced by the user's interests. Next, based on these requirements, we designed a method to quantify the robot's interests. It is said that human interests change over time, increasing due to past behavior, decreasing due to boredom, or becoming stationary6). Additionally, marginal utility is a representative theory in economics that describes changes in consumer utility (satisfaction).

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番組の視聴履歴を用いたテレビ視聴ロボットの興味変化モデルの検討

Study of Interest Change Model for TV-Watching Companion Robots Using Program Viewing History

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あらまし　ユーザの番組視聴履歴からテレビ視聴ロボットの興味を生成，変化させる手法を提案する．ロボットとユーザが5年間一緒にテレビを視聴した想定のシミュレーションを行った結果，ロボットの興味はユーザと類似しつつ，独自の興味を持つことを確認した．

キーワード：コミュニケーションロボット，個性，興味ワード，視聴履歴

1．ま　え　が　き

テレビを複数人で視聴することは，番組から得られる楽しさだけでなく，番組をきっかけとした人同士のコミュニケーションや感情の共有，同じ時間を過ごすことなどによる楽しさや新たな気づきを創出する効果があると考えられる．しかし，日本の平均世帯人員は減少している[1]ことに加え，スマートフォンなどさまざまな視聴デバイスの普及に伴う視聴スタイルの多様化[2]などにより，複数人によるテレビ視聴の機会は減少傾向にある．

そこで筆者らは，現在の視聴スタイルに合った“お茶の間視聴”の再現を目的に，一緒にテレビを視聴し番組内容に応じた発話と対話が可能なコミュニケーションロボット（テレビ視聴ロボット）の研究開発を進めている[3]．

ロボットが家庭において家族と同様に長期間一緒に過ごすためには，ユーザに応じてロボットの発話や動作の内容が異なるなど，ユーザにとって愛着のある存在となることが重要と考えている．本稿では，ユーザがロボットに愛着を持ち，コミュニケーションに飽きを感じないために，ロボットがユーザと一緒に見た番組の視聴履歴からロボットの興味を生成し，それを継続的に変化させる手法（興味変化モデル）を提案する．今回，ユーザの5年間の視聴データを元に，提案モデルを搭載するロボットとユーザが一緒にテレビを視聴した想定のシミュレーションを行い，提案モデルの有効性を確認した．

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2．テレビ視聴ロボットの個性の付与

テレビ視聴は日常的な行為であることから，ロボットを継続的に利用してもらうための検討が必要となる．川那子ら[4]は，ユーザとの長期的なコミュニケーションを通じてロボットの個性となる性格を形成することにより，ロボットの印象や愛着が向上することを明らかにした．また，内田ら[5]は，ロボットが幼児のように知識のない状態からユーザの発話を手がかりに新しいキーワードを獲得し成長することで，幅広いユーザがロボットに対し「かわいらしい」や「親しみやすい」などの印象を感じることを示した．

筆者らは，これらの既存研究に基づき，テレビ視聴ロボットにおいてもテレビ視聴を通して，ユーザ毎に異なる個性（興味）を持たせることで愛着が生まれ，その個性（興味）を継続的に変化させることが，ユーザの長期的な利用につながるという仮説を立てた．

3．ロボットの興味変化モデルの提案

3.1　興味変化モデルの設計

テレビ視聴ロボットの興味変化モデルの設計にあたり，仮説を基に要件を整理した．

①ロボットはユーザとは異なる独自の興味も持つ．

②ユーザと一緒に見た番組によって興味が変化する．

③ロボットの興味は，ユーザの興味の影響を受ける．

次にこれら要件に基づき，ロボットの興味を数値化する手法を設計した．

人の興味の時間的変化は，過去の行動に感化されて増加する，飽きによって減少する，もしくは定常的になることがあると言われている[6]．また，消費者の効用（満足度）の変化を表す経済学の代表的な理論として，限界効用が挙げ

7) Marginal utility indicates the increase in consumer satisfaction obtained when one unit of the same product is consumed. The increase in satisfaction differs depending on the number of times of consumption. The authors consider watching a program to be consumption, and apply marginal utility to the generation of interest in a robot. In addition, since there are generally few opportunities to broadcast and watch the same program, they position the keywords related to the program watched, rather than the program itself, as the product in marginal utility, and calculate the function of the time series change in the robot's interest level for each keyword (interest We decided to generate a taste intensity increase/decrease function.

3.2 Generation of interest increase/

decrease function Viewed programs were identified using the user's personal viewing history (individual record), and keywords were extracted from the program titles and summaries in the EPG (electronic program guide) of the programs viewed. In addition, the interest increase/decrease function was generated using the program history of a specific individual (individual record separate from the user). An example of generating an interest increase/decrease function and installing it in a robot is shown in Figure 1.

All keywords contained in the EPG of each individual record are extracted (Fig. 1, ÿÿ), and the interest level and number of views for each keyword on a monthly basis are calculated (Fig. 1, ÿ). The interest level is calculated using an interest estimation method8). Then, based on the interest level and number of views for each keyword calculated from the individual records for each month, the change in interest is calculated, which increases or decreases each time the robot views each keyword (Fig. 1, ÿ). The formulas for calculating the interest level *intwi ,mj* for a keyword *wi* in a certain month *mj* and the change in interest incwi,mj for the number of views Cwi, *mj* are as follows:

$$incw_{i,m_j} = \frac{(int_{w_i m_j} - int_{w_i, m_{j-1}})}{c_{w_i, m_j}}$$

Here, incwi ,mj-1 is the interest level for keyword wi in the previous month mj-1 , and i and *j* are natural numbers. This calculates the degree of change in interest, which is added up each time the robot views keyword wi once. Additionally, incwi ,mj is the degree of change in interest, which is added up until the robot views keyword wi *Cwi ,mj* times , and the degree of change in interest after the Cwi,mjth viewing is calculated based on the interest level and number of viewings in the following month mj+1 . Using these methods, the degree of change in interest for each keyword in the individual records for all months is calculated.

The robot calculates the number of times each keyword was viewed from the user's individual record, and adds up the interest change degree based on the number of times it was viewed (Figure 1 ÿ).

This makes it possible to create a robot that can reproduce the changes in interests of individual users.

4. Simulation of changes in robot interests

4.1 Simulation Settings

We conducted a simulation in which a robot equipped with the proposed interest change model and a user watched TV together for five years. To generate the interest rate increase/decrease function for the robot, we used individual data from a single man living alone (ages 26-30, five years). The individual data were collected by Intage Inc. from 2016 to 2019.

Viewing history of programs from NHK and five commercial broadcasters collected in 2020

Figure 1 Example of how to generate an interest level increase/decrease function

We used "i-SSP (Intage Single Source Panel)". The robot was equipped with 200,065 keywords, which were extracted from EPG information data of programs broadcast in the past five years.

We used the individual records of the following three users with different attributes to simulate their television viewing behavior over a five-year period.

•User 1: A woman (50-54 years old) who is a married couple and has a child. •User 2: A married man (40-44 years old) •User 3: A single man (27-31 years old) who lives alone.

4.2 Simulation Results To confirm the

similarity between the interests of the robot and the user, we calculated the cosine similarity of the interest level for all keywords. The user's interest level for each keyword was calculated by extracting keywords from the subtitles and EPG information data of the programs the user watched , and using an interest estimation method8). Figure 2 shows a graph showing the change in similarity between the robot and each user over a five-year period.

As shown in Figure 2, user ÿ has attributes similar to those of the individual records used to generate the robot's interest level increase/decrease function, and so the similarity was relatively high from the first month, reaching a high level of over 0.6 by the 13th month. After the 13th month, there was no tendency for the similarity to increase, and the similarity was over 0.5.

られる[7]．限界効用は，同一の製品を一単位消費したときに得られる消費者の満足度の増加分を示す．また消費回数によって増加する満足度は異なる．筆者らは，番組の視聴を消費と捉え，限界効用をロボットの興味生成に適用することとした．また，一般的に同一の番組を放送・視聴する機会はほとんどないため，番組ではなく視聴した番組に関連するキーワードを限界効用における製品と位置づけ，キーワード毎にロボットの興味度の時系列変化の関数（興味度増減関数）を生成することとした．

3.2　興味度増減関数の生成

視聴した番組は，ユーザの個人の視聴履歴（個票）を用いて特定し，キーワードは，視聴した番組のEPG（電子番組表）の番組名や概要文から抽出することとした．また，興味度増減関数の生成には，特定の個人が視聴した番組履歴（ユーザとは別の個票）を用いる方法とした．興味度増減関数の生成とロボットへ搭載する例を図1に示す．

個票のEPGに含まれるキーワードをすべて抽出し（図1①②），全キーワードの月単位の興味度と視聴回数を算出する（図1③）．キーワードの興味度の算出方法は，興味推定手法[8]を用いることとした．そして，個票から算出した各月のキーワードの興味度と視聴回数に基づき，各キーワードをロボットが視聴する毎に増減させる興味の変化度を得る（図1④）．ある月m_jのキーワードw_iの興味度int_{w_i,m_j}と，視聴回数C_{w_i,m_j}に対する興味の変化度inc_{w_i,m_j}の計算式は以下の通りである．

$$inc_{w_i,m_j} = \frac{(int_{w_i,m_j} - int_{w_i,m_{j-1}})}{c_{w_i,m_j}}$$

ここで，$inc_{w_i,m_{j-1}}$はキーワードw_iにおける前月m_{j-1}の興味度であり，iとjは自然数である．これにより，ロボットがキーワードw_iを1回視聴する毎に足し合わせる興味の変化度が算出される．また，inc_{w_i,m_j}はロボットがキーワードw_iをC_{w_i,m_j}回視聴するまで足し合わせる興味の変化度であり，視聴回数がC_{w_i,m_j}回目以降の興味の変化度は，翌月m_{j+1}の興味度と視聴回数に基づき算出する．これらの方法により，個票にある全月の各キーワードの興味の変化度を算出する．

ロボットは，ユーザの個票から各キーワードの視聴回数を算出し，視聴回数に基づき，興味変化度を足し合わせていく（図1⑤）．これにより，興味度増減関数の生成で用いた個票の興味の変化を再現したロボットが実現できる．

4．ロボットの興味の変化のシミュレーション

4.1　シミュレーション設定

提案する興味変化モデルを搭載したロボットと，ユーザが5年間，一緒にテレビを視聴した場合のシミュレーションを行った．ロボットの興味度増減関数を生成するために，ある独身で一人暮らしの男性（26～30歳の5年間）の個票を用いた．個票には株式会社インテージが2016年から2020年に収集したNHKおよび民放5局の番組の視聴履歴

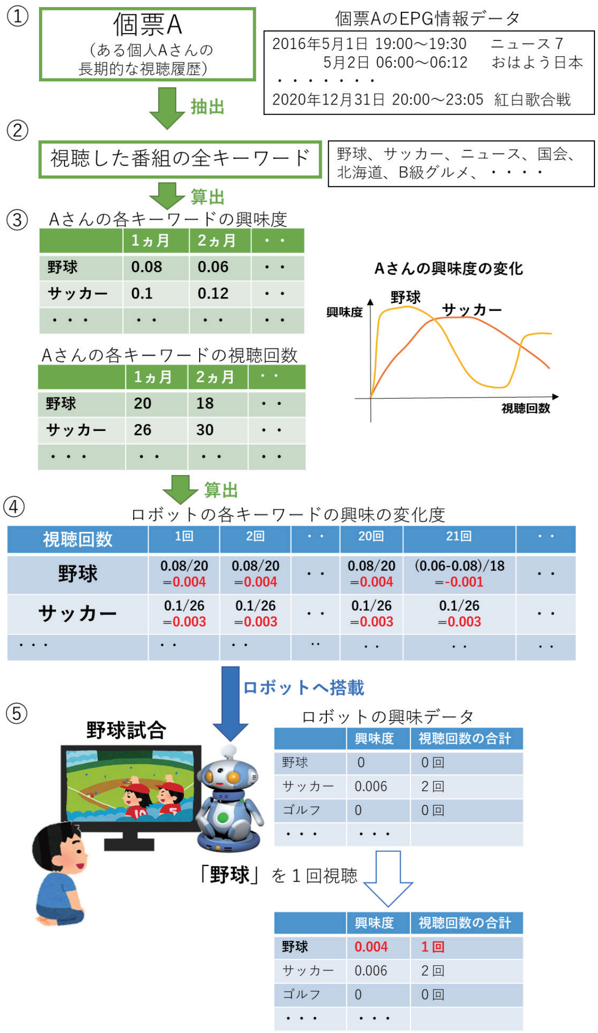

図1　興味度増減関数の生成方法の例

「i-SSP（インテージシングルソースパネル）」を用いた．ロボットに搭載したキーワード数は200,065ワードであり，過去5年間で放送された番組のEPG情報データから名詞を抽出したものである．ロボットと一緒にテレビを視聴するユーザとしては，属性の異なる以下の3ユーザの個票を用い，5年間のテレビ視聴を模擬した．

・ユーザ①：夫婦と子供の三人家族の女性（50～54歳）
・ユーザ②：夫婦二人暮らしの男性（40～44歳）
・ユーザ③：独身で一人暮らしの男性（27～31歳）

4.2　シミュレーション結果

ロボットとユーザの二つの興味の類似性を確認するため，すべてのキーワードの興味度のコサイン類似度を算出した．ユーザの各キーワードに対する興味度は，ユーザの視聴した番組の字幕とEPG情報データからキーワードを抽出し，興味推定手法[8]により求めた．ロボットと各ユーザの5年間の類似度の変化を表したグラフを図2に示す．

図2より，ユーザ③はロボットの興味度増減関数の生成に用いた個票の属性に近いこともあり，1ヵ月目から類似度は比較的高く，13ヵ月目には0.6以上と高い結果となった．13ヵ月目以降は高くなる傾向はなく，0.5以上の類似

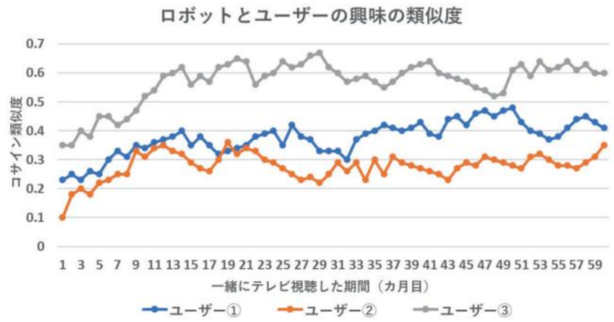

Figure 2. Changes in similarity between robots and users over a five-year period

User 1 has also maintained a score of 0.3 or higher since the seventh month. User 2 is more interested in

Taste similarity is low, but tends to increase from the beginning to the 9th month. From the 9th month onwards, the similarity between the interests of the user and the robot was higher than in the early stages. In addition, because the degree of similarity varied depending on the user, it was confirmed that the degree of empathy for each other's interests differed for each user.

Check the time changes of keywords that the robot is interested in

To this end, Figure 3 shows a word cloud of keywords of high interest for the robot and user one month and five years after they started watching TV. The size of the keyword represents the level of interest, with keywords common to the user and robot shown in color, and different keywords shown in black. The results are for two users, User ÿ, who tended to have low

similarity, and User ÿ, who tended to have high similarity. Figure 3 shows that User ÿ only had one common keyword one month after they started watching TV together, but five years later many common keywords appeared, such as "TV series" and "news." On the other hand, the robot had many similar keywords, such as "Rakuten" and "fashion."

User 3 had high similarity from the beginning, and four common keywords such as "music" and "gold medal" appeared in the first month, and after five years, even more common keywords such as "theme song," "land," and "America" appeared.

On the other hand, the robot has user preferences such as "sushi" and "resorts." Keywords different from those in 3) appeared.

From the above, we confirmed that by watching TV together with the user, the robot is influenced by the user's interests, and while it has common interests, it also has its own interests, which change over time. We also confirmed that a robot with different interests can be generated for each user.

5. Conclusion

In this paper, we proposed a model of how interests change in a robot watching TV with a human, and performed a simulation assuming that the robot watched TV with the user for five years. As a result, we confirmed that as the robot continued to watch TV with the user, the robot's interests became similar to those of the user, while also acquiring its own interests. We also confirmed that robots with different interests (personalities) were generated for each user. In the future, we will implement this model in a TV-watching robot and investigate whether it is possible to make the robot feel attached to people by having it speak based on its own interests.

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Figure 3 Robot and user interest keywords

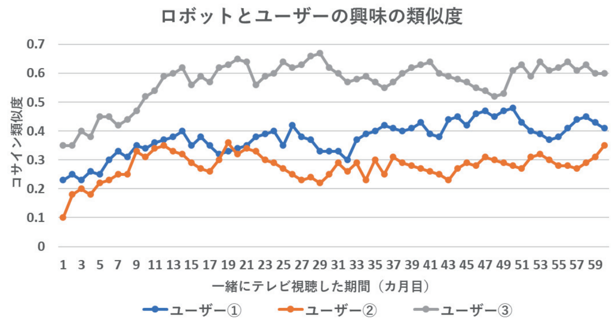

図2　ロボットとユーザの5年間の類似度の変化

度を保っている．ユーザ①においても，7ヵ月目以降は0.3以上を保ち続けている．ユーザ②は他のユーザと比べて興味の類似度が低いが，初期から9ヵ月間は，上昇する傾向が見られ，9ヵ月以降は初期よりもユーザとロボットの興味の類似度が高いことがわかる．また，ユーザによって類似度に差があることから，お互いの興味に対して共感する度合いがユーザ毎で異なることを確認した．

ロボットが興味を持ったキーワードの時間的変化を確認するため，ロボットとユーザがテレビ視聴を始めて1ヵ月後と5年後の興味度の高いキーワードをワードクラウドで図3に示す．キーワードの大きさは興味度の高さを表現しており，ユーザとロボットで共通のキーワードは有彩色，異なるキーワードは黒色で示す．

ユーザは類似度が低い傾向にあったユーザ②と，高い傾向だったユーザ③の2人の結果である．図3より，ユーザ②は一緒にテレビ視聴を始めて1ヵ月目は共通するキーワードは一つしか見られないが，5年後には「連続テレビ小説」や「ニュース」など共通のキーワードが多数出現した．一方，ロボット側には「楽天」や「ファッション」など，ユーザ②とは異なるキーワードが出現した．ユーザ③では，初めから類似度が高いことから，1ヵ月目で「音楽」や「金メダル」など四つの共通するキーワードが出現し，5年後には「主題歌」や「ランド」，「アメリカ」など共通のキーワードがさらに多く出現した．

一方，ロボット側には「寿司」や「リゾート」などのユーザ③とは異なるキーワードが出現した．

以上により，ロボットはユーザと一緒にテレビ視聴をしたことで，ユーザの興味の影響を受けて，共通の興味持ちつつ，独自の興味も持ち，時間とともに変化していくことを確認した．また，ユーザ毎に興味が異なるロボットが生成されることを確認した．

5．む　す　び

本稿では，人と一緒にテレビを視聴するロボットの番組への興味変化モデルを提案し，ロボットがユーザと5年間テレビ視聴をした想定のシミュレーションを行った．その結果，ロボットはユーザとテレビ視聴をし続けることで，ロボットの興味がユーザの興味に類似していきつつ，独自の興味も獲得していくことを確認した．また，ユーザ毎に興味（個性）が異なるロボットが生成されることも確認できた．

今後は，テレビ視聴ロボットに本モデルを実装し，ロボットに自身の興味に基づいた発話をさせることで，人に愛着を感じさせることができるか調査していく．

〔文　献〕

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