Tangible Fidgeting Interfaces for Personalised Real-World Affective Modelling

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Introduction

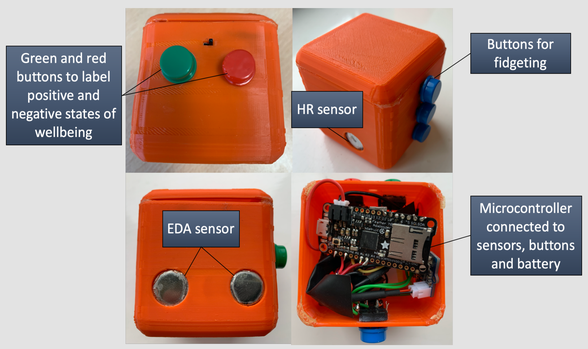
Modern lifestyles are heavily contributing to increased levels of daily stress and poor mental wellbeing making the management of real-world wellbeing more vital than ever.

Fidgeting is a common response to stress and is often used as a coping strategy as repetitive interactions help tap into an individual's psychological need to feel occupied.

On the other hand, recent developments in non-invasive physiological sensors paired with deep learning classifiers introduce the possibility to quantify mental wellbeing in real-time, paving the way to continuously and non-invasively monitor wellbeing.

Tangible Fidgeting Interfaces

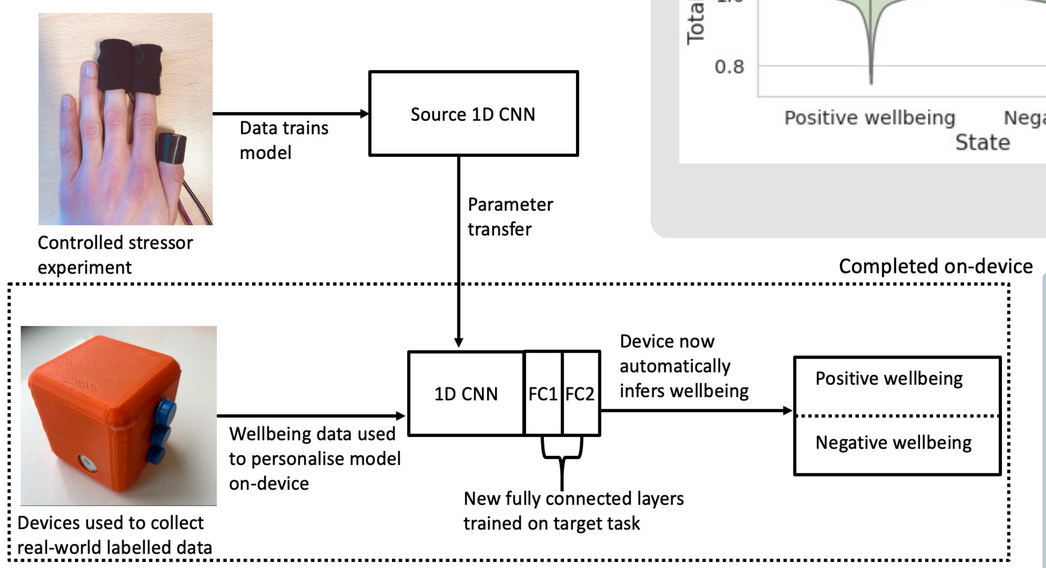
This research introduces the concept of Tangible Fidgeting Interfaces (TFIs) as custom-built physical fidgeting devices that enable repetitive physical interaction while also enabling real-world objective physiological and motion sensor measurement. These fidgeting interfaces can be coupled with deep learning algorithms, paving the way for a new type of real-time interaction.



On-device Personalisation TL Methodology

A Transfer Learning (TL) approach has been developed to personalise real-world affective models, classifying positive and negative mental wellbeing from the time-series sensor data by adapting a controlled stressor source 1D CNN model.

This TL approach advances on previous state-of-the-art approaches by alleviating many of these challenges traditionally associated with affective modelling by only requiring few real-world labelled samples, which can then be used to automatically develop personalised models on-device. Collecting a small, labelled dataset directly from the TFI and then personalising models on-device significantly simplifies the process of developing the personalised, real-world affective models.



Results

Adopting the TL approach significantly increased model performance with the highest accuracy achieved using the TL 1D CNN fusing physiological and motion data. These TL models achieved an average accuracy of 93.47%, 21.8% higher than the comparative 1D CNN trained without the TL approach.

When using solely motion data to infer wellbeing, an average accuracy of 88.05% was achieved using the TL approach, again outperforming the equivalent non-TL model. This shows changes in fidgeting behaviours can be used to infer wellbeing.

Table 1: Comparison of target user multivariate physiological models

	Non-TL Accuracy	TL Accuracy	TL AUC
User 1	74.1%	84%	86.2%
User 2	85.1%	90.4%	90.6%
User 3	72.5%	99.6%	99.6%
User 4	85.5%	95.8%	91.6%
User 5	86.2%	90.6%	90.7%
User 6	83%	93.5%	92%
User 7	85.3%	89%	89%
User 8	83.8%	91%	95%
User 9	87 %	97%	92%
Average	82.5%	92.3%	91.9%

Table 2: Comparison of target user multivariate physiological and motion models.

	Non-TL Accuracy	TL Accuracy	TL AUC
User 4	87%	96.3%	86.9%
User 5	79%	89.2%	89.2%
User 6	81.1%	90.3%	86.6%
User 7	54.8%	91%	91%
User 8	50%	96%	98%
User 9	78.3 %	98%	99%
Average	71.7%	93.5%	91.8%

Table 3: Comparison of target users' univariate motion models.

	Non-TL Accuracy	TL Accuracy	TL AUC
User 4	86%	89.1%	72.3%
User 5	80%	72.4%	72.6%
User 6	73%	82.8%	75.4%
User 7	27%	90%	90%
User 8	69%	97%	89%
User 9	74 %	97%	89%
Average	68.2%	88.1%	81.4%

Conclusion & Future Work

Overall TFIs present new methods of real-world physiological data collection whilst simultaneously enabling fidgeting interactions that participants found “calming” and “relaxing”, helping to improve mental wellbeing.

The proposed TL methodology helped overcome problems with real-world affective model personalisation, thus improving on the performance of conventional deep learning methods.

This approach creates the opportunity for future research applications to infer real-world wellbeing for the wider population without the need to first collect large, labelled datasets, greatly improving accessibility to personalised affective models. In the future, TFIs should be trialled with more users over a longer period of time to collect additional data and further explore the impact of fidgeting on wellbeing.

For further details, visit the articles or scan the QR Code

Woodward, K., & Kanjo, E. (2020). iFidgetCube: Tangible Fidgeting Interfaces (TFIs) to Monitor and Improve Mental Wellbeing. IEEE Sensors Journal.
Woodward, K., Kanjo, E., Brown, D. J., & McGinnity, T. M. (2021). Towards Personalised Mental Wellbeing Recognition On-Device using Transfer Learning “in the Wild.” IEEE International Smart Cities Conference 2021.