Any-Precision Deep Neural Networks on Android

High-precision arithmetics may unnecessarily overburden mobile devices with limited computational capabilities. Any-Precision method enables flexible execution of deep neural networks, so that network parameters at runtime can be set to different bit-widths, by truncating the least significant bits (see https://www.aaai.org/AAAI21Papers/AAAI-419.YuH.pdf). Unfortunately, Any-Precision networks are not immediately usable on mobile devices. First, the method requires a layer that enables operations on quantized operators. Second, the actual operations should be executed in a manner that actually enables resource savings on the target device. Certain steps along the above lines have already been taken, yet, they require PyTorch and CUDA GPUs (not available on mobiles). In this project you will investigate the opportunities for precision-flexible execution on mobiles, you will then implement a selected method enabling Any-Precision networks, and finally demonstrate it on a simple use case of your choice. The resulting code should be released as an open-source project.

Where's my (phone's) energy?

Limited battery capacity is one of the biggest issues preventing further growth of mobile computing. In this work you will develop an app that senses the context of use and the energy used in a phone. From the collected data you should extract rules on how the energy is being used in different contexts and provide guidelines that will help users optimize their energy use (e.g. most of the energy is used for playing a 3D game during your daily commute on a bus, consider listening to podcasts instead). You will also have access to a high-precision power meter in the lab.

Related work:

- Falaki, Hossein, et al. "Diversity in smartphone usage." Proceedings of the 8th international conference on Mobile systems, applications, and services. 2010.

Wireless gesture recognition for mobiles using software defined radio

Gesture recognition is a powerful new interaction modality that is likely to become increasingly popular as the efforts to prevent disease transmission grow. The goal of this project is to build a gesture recognition system that runs on a mobile device. A software-defined radio frontend, such as HackRF or Ettus Research USRP is connected to a smartphone running GnuRadio software for signal processing. Then, machine learning algorithms need to be trained to connect the sensed wireless signals with specific gestures that a user performs. During the testing time, the mobile app should recognise gestures in real time.

Related work:

- Pu, Qifan, et al. "Whole-home gesture recognition using wireless signals." Proceedings of the 19th annual international conference on Mobile computing & networking. 2013.
- https://www.rtl-sdr.com/gnu-radio-code-for-android-now-released/

NOTE: Getting GnuRadio to run on a mobile and learning the basics of GnuRadio are needed for this project to be completed. Therefore, the project is suggested for a group of more than two students.

Folk-knowledge collector

Local folk knowledge about land use and natural resource preservation may hold the answers to some of the most pressing issues of the 21st century, such as the global climate crisis. Unfortunately, this knowledge is often not written down, nor widely available. In this project you will develop an app that enables documentation of folk knowledge (in Slovenia). The app should enable geo-tagged recording of images and sounds, and image and sound analysis (object/keyword extraction).

Related work:

- Pejovic, Veljko, and Artemis Skarlatidou. "Understanding Interaction Design Challenges in Mobile Extreme Citizen Science." International Journal of Human–Computer Interaction 36.3 (2020): 251-270.

Evaluating user's mood through smartphone-assisted storytelling

Storytelling is a universal, age-old tradition credited to contribute to the well-being of the storyteller while representing an element of intergenerational heritage for the listeners, through its historical and social content. In light of the recent ICT advances, the term digital storytelling was introduced, where digital technologies and devices assist the narrator in creating stories with digital content.

The goal of this project is to develop a personal assistant (e.g. using Google Assistant technology) capable of natural language conversation with the user, which engages him in digital storytelling sessions (i.e. brief chats in which the agent is asking questions that would stimulate the user to express his feelings and thoughts). The target group will be formed of University students and two scenarios/discussion topics are envisioned: one in which the agent asks the users about their opinion and personal experiences with regard to the current epidemiological context and the other regarding their future career plans after graduating. The app then applies Tone/Sentiment analysis services to identify the emotional tone (e.g. anger, fear, joy, sadness) and the sentiment (negative, neutral, or positive) of the user's feedback. You are supposed to use a conversational agent framework, e.g. Actions on Google, and integrate cognitive computing services, e.g. IBM Watson for Tone/Sentiment analysis.

The app will be evaluated by a group of users, which will then be questioned about their mood by filling in a survey/questionnaire (e.g. Mood and Feelings questionnaire) and also questioned about their perception on the interaction with the conversational agent. The correlation between the app's findings about the user's mood and the results of the questionnaire will be analysed, together with the way users relate to the conversational agent (perceived sense of immersion in the experience, to what extent they view the agent as a social entity, etc.)

Related work:

- Atzeni, Mattia, and Diego Reforgiato Recupero. "Deep learning and sentiment analysis for human-robot interaction." In European Semantic Web Conference, pp. 14-18. Springer, Cham, 2018.
- Clavel, Chloe, and Zoraida Callejas. "Sentiment analysis: from opinion mining to human-agent interaction." IEEE Transactions on affective computing 7, no. 1 (2015): 74-93.
- Machidon, Octavian-Mihai, Aleš Tavčar, Matjaž Gams, and Mihai Duguleană. "CulturalERICA: A conversational agent improving the exploration of European cultural heritage." Journal of Cultural Heritage 41 (2020): 152-165.

Smart assistant that discerns between recorded and live voice

Smart assistants (e.g. Google Assistant, Siri, Alexa) can interact with the users via voice commands and can even learn to recognise the device owner's voice. However, an adversary can record the voice and replay the commands, thus tricking the assistant into executing a non-intended command. In this project you should develop a method for discerning between live voice and a recording. The method should be based on the analysis of the sound detected by a mobile device. Test the method with at least three different speakers and five different users.

Related work:

- Blue, Logan, Luis Vargas, and Patrick Traynor. "Hello, Is It Me You're Looking For? Differentiating Between Human and Electronic Speakers for Voice Interface Security." Proceedings of the 11th ACM Conference on Security & Privacy in Wireless and Mobile Networks. 2018.

Anxiety tracking

Develop an app for tracking a user's context, such as their interaction with other people, movement patterns, sleeping behaviour, and simultaneously collect information about a user's perceived anxiety through experience sampling on the phone (a short questionnaire). You should collect information from at least 14 users over two weeks and analyze it to uncover potential links between the anxiety and contextual factors.

Related work:

- Obuchi, Mikio, et al. "Predicting Brain Functional Connectivity Using Mobile Sensing." Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies 4.1 (2020): 1-22.
- Wang, Rui, et al. "StudentLife: assessing mental health, academic performance and behavioral trends of college students using smartphones." *Proceedings of the 2014 ACM international joint conference on pervasive and ubiquitous computing*. 2014.

Sensed data visualisation in virtual reality

Develop an interactive VR-based visualisation of sensor data collected via a smart wristband and a phone. The user should be able to see her heartbeats, step count, heart rate variability, and ideally some high-level metrics, such as sleep duration, in the VR environment in near real time. The visualisation should be performed in 1) aesthetically pleasing, 2) computationally clever manner. For instance, you should build upon the theory of synesthesia, dimensionality reduction, etc.

Related work:

- Petrakos, Michalis, Walter Dicarlo, and Ioannis Kanellopoulos. "Projection pursuit and a VR environment for visualization of remotely sensed data." IEEE 1999 International Geoscience and Remote Sensing Symposium. IGARSS'99 (Cat. No. 99CH36293). Vol. 5. IEEE, 1999.
- https://en.wikipedia.org/wiki/Synesthesia

Note: requires the basic knowledge of VR design frameworks, such as Unity.

Note: alternatively, you can also focus on sonification of the sensor data. In this case, Xenakis' UPIC system that translates visual data to sounds could be of use https://en.wikipedia.org/wiki/UPIC

Federated learning for user authentication on mobile phones

User authentication on mobile devices is often cast as one-class classification problem as, due to privacy issues, only the identifying user's data are processed on one device. More robust models could be constructed if data from multiple users is harnessed, yet privacy issues prevent such data aggregation on a server. Federated learning allows a common machine learning model to be built over multiple devices without raw data sharing. In this project you will implement a federated learning-based authentication method in Android. You may use an existing federated learning framework, such as https://flower.dev/ and mimic the state-of-the-art federated authentication approaches, such as https://ieeexplore.ieee.org/abstract/document/9484338