Opportunity for two Master Theses

*offered as a collaboration between the **Research group of Primate Behavioural Ecology** (Prof. Anja Widdig, Institute for Biology at UL), the Earth & Environmental Sciences group at **ScaDS.AI** (Dr. Josefine Umlauft) and the **Image and signal processing group** (Dr. Christina Gillmann, Institute for informatics at UL)*

Topic

Understanding the link between social behaviour and genetic relatedness in primates using machine learning models.

Background

Genetic relatedness is a major force shaping sociality in group-living primates. Most primate species live in groups consisting of several males and females, with both sexes mating highly promiscuously leading to complex kin networks. Some pairs of animals share the same mother or maternal family, while others share the same father or paternal family with a considerable proportion of animals being related over both the maternal and paternal side. However, as primate offspring are typically raised only by their mothers and maternal kin, it is reasonable to ask whether individuals are able to recognize their fathers and whether they are aware of their paternal siblings, i.e. individuals they share the same father with or other paternal kin?

Past research of our research group working on different macaque species for example

rhesus macaques (*Macaca mulatta*)  or


crested macaques (*Macaca nigra*)

has shown that animals recognize their relatives and prefer them in different behavioural contexts, e.g. they share food with them more often or support them more likely when involved in aggressive conflicts as predicted by early theoretical models (kin selection, Hamilton, 1964). Moreover, it has been shown that monkeys can identify their kin when presented with a single visual, vocal or chemical cue, even kin they have never met before, which implies that they match phenotypes to identify kin (Pfefferle, Kazem, et al., 2014; Pfefferle, Ruiz-Lambides, et al., 2014). Taking advantage of machine learning, recent studies in mandrills (*Mandrillus sphinx*) using deep neural networks showed that related individuals have a higher facial similarity than unrelated subjects, which could also explain preferences observed at the behavioural level (Charpentier et al., 2020, 2022).

However, so far no study has yet used **machine learning to classify similarity in vocal and visual signals in macaques according to their relatedness**. This will be especially exciting when kinship is measured by **whole genome sequencing**, which includes information across the whole genome and thus results in the most comprehensive measure of relatedness. This allows us not only to measure the

total DNA shared between individuals but also identify if individuals share the same alleles for specific genes encoding important phenotypic traits.

Hence, we offer TWO Master theses for well-trained students in the field of bioinformatics, computer sciences or mathematics with high interest in Evolutionary Biology and Behavioural Ecology. We provide relatedness data from whole genome sequencing and high quality, standardized vocal and visual recordings of free-ranging rhesus macaques living on Cayo Santiago (Puerto Rico/USA), one of the most detailed studied primate population in the world, to investigate the vocal and visual profiles with regard to relatedness.

After a literature search and introduction to the project, students will overlook either vocal and visual profiles provided, pre-process the data and train a machine learning model accordingly.

Requirements

The potential candidates will require

- Bachelor's degree in bioinformatics, computer science, mathematics or related fields
- high interest in Evolutionary Biology and Behavioural Ecology
- advanced skills in a script based programming language (ideally Python)
- pre-knowledge in machine learning and state-of-the-art machine learning libraries (e.g., scikit-learn, Pytorch or Tensorflow) is advantageous

Time schedule

Ideally, the project should start in March with two students being in charge of either the processing of the vocal or the visual data. Results should be obtained during the summer with flexible writing up periods.

Please contact Dr. Josefine Umlauft josefine.umlauft@uni-leipzig.de and Prof. Anja Widdig anja_widdig@eva.mpg.de **(for acoustic)** and to Christina Gillmann gillmann@informatik.uni-leipzig.de and Prof. Anja Widdig anja_widdig@eva.mpg.de **(for vision)** if you are interested please contact us.

References

Charpentier, M. J. E., Harté, M., Poirotte, C., Bellefon, J. M. de, Laubi, B., Kappeler, P. M., & Renoult, J. P. (2020). Same father, same face: Deep learning reveals selection for signaling kinship in a wild primate. *Science Advances*, *6*(22), eaba3274. https://doi.org/10.1126/sciadv.aba3274

Charpentier, M. J. E., Poirotte, C., Roura-Torres, B., Amblard-Rambert, P., Willaume, E., Kappeler, P. M., Rousset, F., & Renoult, J. P. (2022). Mandrill mothers associate with infants who look like their own offspring using phenotype matching. *ELife*, *11*, e79417. https://doi.org/10.7554/eLife.79417

Hamilton, W. D. (1964). The genetical evolution of social behaviour I/II. *Journal of Theoretical Biology*, *7*(1), 1–52. https://doi.org/10.1016/0022-5193(64)90038-4;10.1016/0022-5193(64)90039-6

Pfefferle, D., Kazem, A. J. N., Brockhausen, R. R., Ruiz-Lambides, A. V., & Widdig, A. (2014). Monkeys spontaneously discriminate their unfamiliar paternal kin under natural conditions using facial cues. *Current Biology*, *24*(15), 1806–1810. https://doi.org/10.1016/j.cub.2014.06.058

Pfefferle, D., Ruiz-Lambides, A. V., & Widdig, A. (2014). Female rhesus macaques discriminate unfamiliar paternal sisters in playback experiments – support for acoustic phenotype matching. *Proceedings of the Royal Society B*, *281*(1774), 1–9.