Abstract

It is well known that lizard species such as the *Gekko gecko* and *Mabuya macularia* have evolved an amazingly directional peripheral auditory system that exhibits the strongest directionality of any terrestrial vertebrate's auditory system that has been investigated. The fascinating feature of the system is that it has rather small dimensions in comparison with the wavelengths of the frequencies to which it most sensitive. This implies that the binaural time and intensity cues, generated by the time-of-arrival differences and the sound shadow created by the animal's head, respectively, are rather small. In spite of this fact, the strong directionality has been experimentally determined to be a consequence of the acoustical coupling of the contralateral and ipsilateral tympanal membranes via a hollow Eustacian tube through the mouth cavity. Studies using laser vibrometry have shown that the strong directionality is manifested in the form of tympanal vibrations which are stronger on the side which is nearer to the source of the sound.

The work presented here builds upon recent research on modelling the peripheral auditory system of lizards and on validation of the obtained model coupled with a decision model in phonotaxis tasks through simulation and robotic experiments. Initially, the phonotactic performance of the auditory model is re-investigated through a robotic implementation inspired by Braitenberg vehicles with simple and direct sensorimotor cross-couplings between the auditory model and the actuators. In subsequent experiments, isolated and independent decision models are embedded into the individual sensorimotor cross-couplings, and the phonotactic performance is again investigated. The effect of parameter-scaling on the response of the model is then investigated and the directionality of the scaled models is experimentally determined via a robotic implementation.

In those experiments the robot model has the ability to move freely. However, sound localization based on the implemented strategies fails when movement is not allowed because the auditory cues cannot be directly mapped to the sound direction by such strategies. For a stationary system to localize sound using the auditory model, an internal representation of the sound direction is necessary. In order to automatically generate such a representation, the model is then coupled with a Cerebral Model Articulation Controller based neural network and the system's ability to learn the sound direction representation is investigated.

In all the above-mentioned experiments, the robot model is a wheeled robot. In order to extend the investigation to sensory guidance of bio-inspired locomotion patterns, the model is then coupled to a Central Pattern Generator locomotion model based on the spinal cord of salamanders, and the auditory cues extracted by the auditory model are employed to modulate the parameters of the locomotion model to generate turning motion in phonotaxis tasks. Finally, three dimensional sound localization is investigated via a pan-tilt assembly with three microphones employing two independent auditory models performing sound localization in the horizontal and vertical planes, and preliminary results are presented.