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Acoustic focussing: how flying bats control spatial distribution of Doppler-ranging errors by signal sweep rate

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Echolocating bats obtain three-dimensional images of their surroundings in complete darkness by emitting sonar signals and evaluating returning echoes. When flying close to objects, bats risk collision and therefore depend on the accuracy of images - particularly in the perceived distance of obstacles, which is coded by the time delay between call and echo. Yet, during flight, such accuracy is perturbed first because bats call and receive echoes at different positions and second because echoes are modified by Doppler shifts. The spatial distribution of such ranging errors is range dependent - objects at one particular distance from the bat have zero ranging errors, while ranging-errors increase for closer or more distant objects. Interestingly, this distance of zero ranging error depends on signal design, in particular sweep rate. By adjusting signal design flying bats could shift this distance adaptively to their target of interested. Because this has similarities with focusing (i.e. accommodation) in vision, this distance is called distance of focus (DOF). We will present examples for actual distances of focus of different bat species in different behavioural contexts, such as search flight, obstacle avoidance and target approach. DOF gives a novel perspective to the adaptive relevance of frequency modulated sonar signals.