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EC3134
Assignment 1: Designing Models

Physical phenomenon: Singing Crickets

Model 1:
Model on the physiology of male cricket vocalize

General idea:
Crickets vocalize using structure on their body, by stridulation. The crickets rub parts of their body together (the file against the plectrum) and a resonating structure (the harp) vibrates to produce the sound. This model is being designed to attempt replicating the sound by "copying" the mechanical properties of cricket physiology, which in turn helps us understand the physics behind cricket sound production.

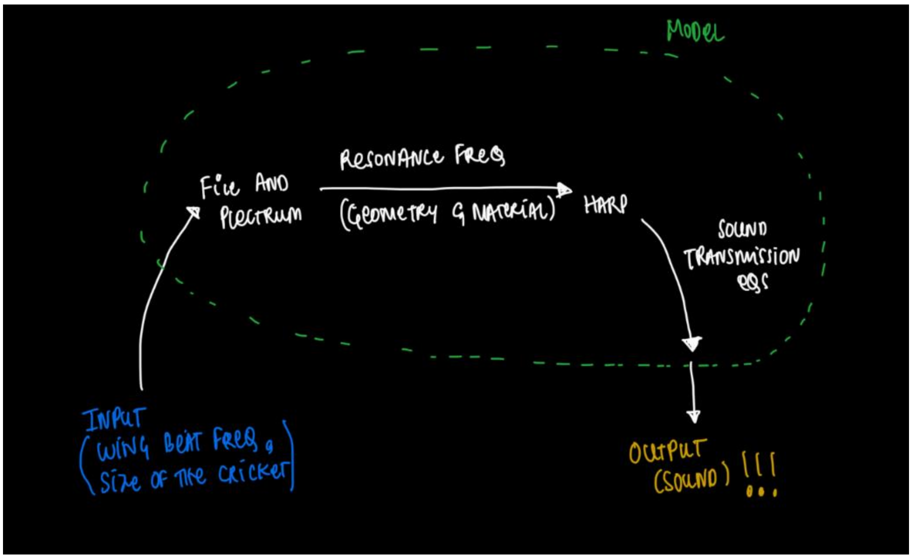
Inputs:
Size of the cricket (proxy of how big the plectrum, the file and the harp are, and thus these can also be the inputs of the model)
Wing beat frequency (this is an input as it is something that is actively controlled by the cricket)

Parameters:
The material properties of the file, plectrum and the harp. These are constrained by the physiology of the animal and material type is assumed to not change between individuals of the same species. These parameters include:
- Body temperature (this can be taken either as a fixed parameter or as an input)
- Bulk modulus of the harp (because this decides the resonance frequency of the harp)
- Geometry of the harp (this also determines its resonance frequency). Geometry is assumed to be constant with only the size varying between different individuals.
- Temperature of the air, its bulk modulus and molecular weight, adiabatic constant, density and gas constant are all assumed to be fixed.
- Force by which the file is rubbed against the harp, which is assumed to be a function of size of the cricket as it depends on the musculature.

Output:
Sound produced by the stridulation. This involves all the characteristics of the sound like frequency of the sound, carrier frequency (which is ecologically relevant for the cricket), song structure (like notes and interval between notes)

Generative process:
This is a Dynamical model. The model uses the physics of sound, to try and understand how crickets use different materials and structures in specific ways to generate the sounds that we hear every night.
The equations involved would be:
- Equations involving the speed of sound, sound transmission.
- Equations that determine the resonance frequency of the harp based on its geometry and the material.

Evaluation process:
The sound output from the model is matched and compared with the sounds of crickets in the wild. We can check if changing size of cricket in the model also matches well with sound produced by crickets of known size.



Model 2:

Model of how male cricket vocalization affect female phonotaxis

General idea:
Vocal signals are important for mate localization which in turn affects mate frequency in the population. The model is an attempt to see the effects of density and population sizes on mate frequency.
This model looks at how female movements change in response to calling males in the population. Crickets are present on bushes and males sing while in a bush, and stay still while calling. Movement between and within bushes is probabilistic for both male and females, females move towards calling males and towards males that sing louder.

Inputs:
Frequency of males calling (because all males don’t call at all times)
Population density and number of individuals
Sex ratio

Parameters:
Plot size over which the model is being run. This is assumed to be fixed and no crickets leave this hard boundary.
The parameters, like probability of movement, are computed from field experiments and it is assumed that this is fixed.

Frequency of a caller. Frequency of call is randomly assigned to different males based on physiologically feasible ranges of frequency.
Temperature of the air, its bulk modulus and molecular weight, adiabatic constant, density and gas constant are all assumed to be fixed. These determine the range sizes of the caller (area within which a female will hear the caller) by determining the attenuation of the call, i.e., how the call decays with distance.
Time of mating. This is taken to be fixed and a female moves on after successful mating. There is a downtime between mating and calling again (to prevent females getting "stuck to a male" in the model) which is also a parameter.

Output:
Phonotaxis of females.

Generative process:
This model is a stochastic/ probabilistic model. The movement of females in the absence of males is completely random and when males are introduced in the model patterns emerge.
The neural wiring of the females as to mate choice when exposed to two different mate sounds (which is decided by the amplitude of the call) also counts as a generative process here.
Equations used to determine the attenuation of sound to determine the range of the male is also a generative process.

Evaluation process:
Recorded movement of the females in the wild is compared to the output of the movements of females as predicted by the model.
Do note that exact matching cannot be made because movement is stochastic and varies greatly in the field, so the comparison needs to be done at a lower resolution, for example, compare mate frequency instead of exact movement patterns.