Adaptive Tone Canceller

AN EXAMPLE SOLUTION

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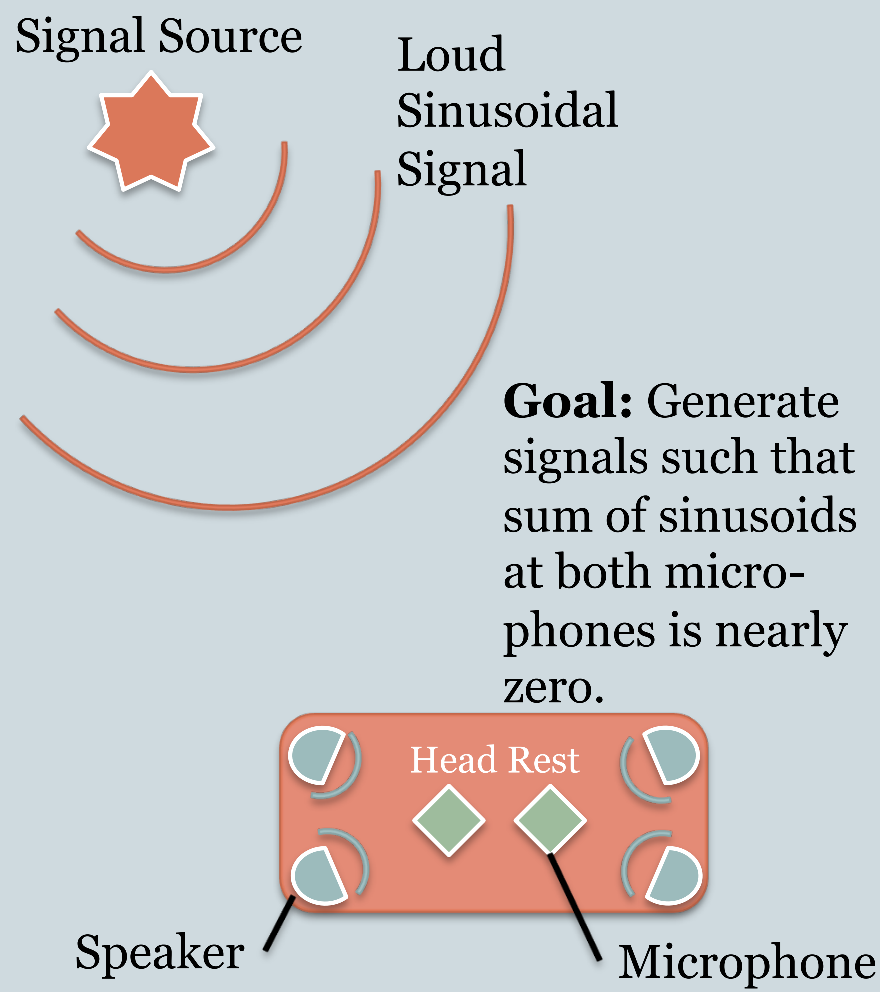
Problem Statement

- A loud sinusoidal signal is to be cancelled at specific locations.
  - Using sinusoids generated by set of speakers.
  - Sum of all sinusoids – loud signal and speakers – is measured by microphones.
- **Objective:** set amplitudes and phases of sinusoids so that signal at both microphones is near zero.



Mathematical Model

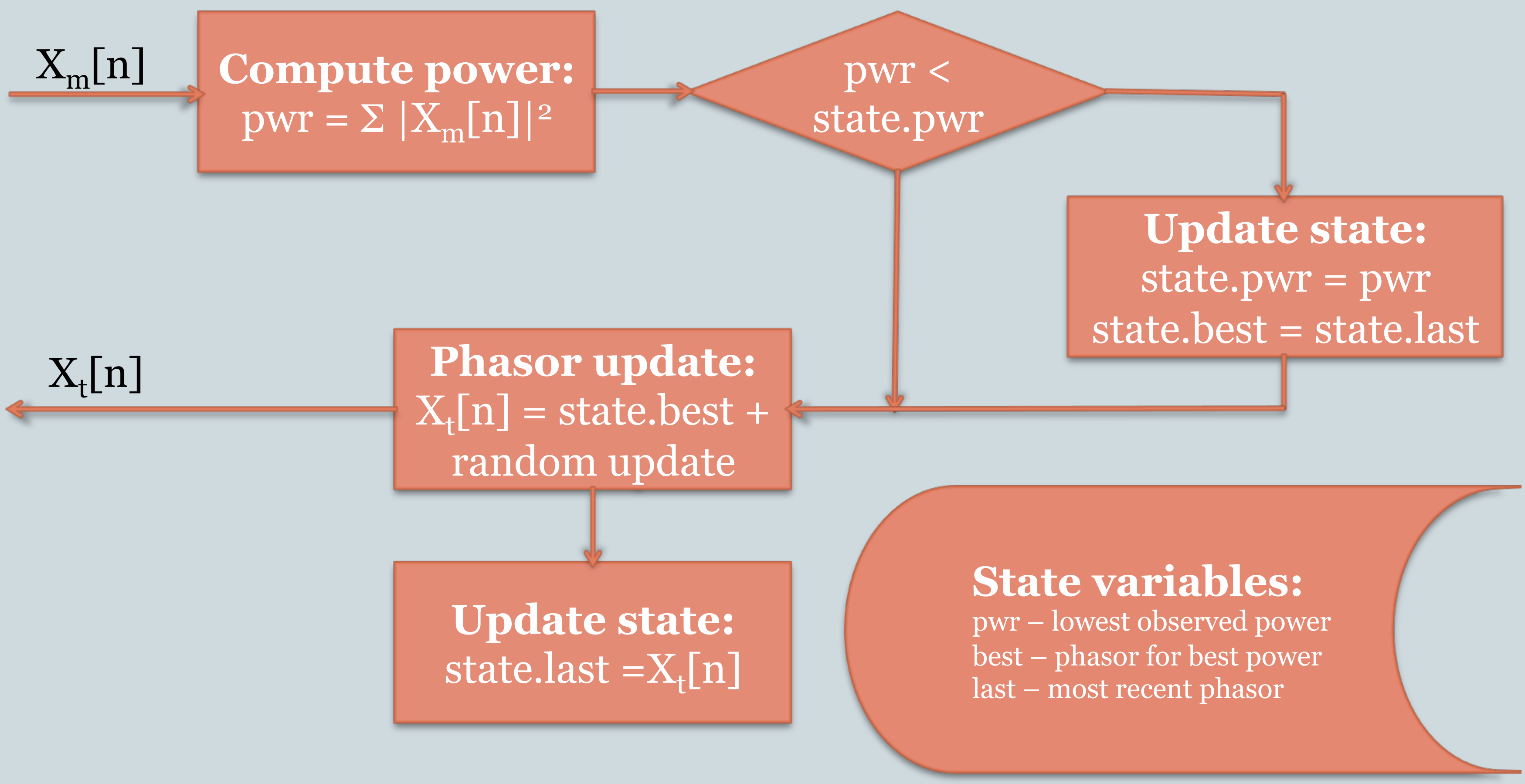
- All relevant signals are sinusoids of the same frequency:
  - Therefore, signals are characterized completely by phasors.
  - Sum of sinusoids corresponds to phasor sum.
- The system works on 25ms blocks of signals.
- The system measures the phasors $X_m[n]$ during the n-th block at both microphones.
- The measured phasors are provided to the adaptive canceller.
- The canceller sets the phasors $X_t[n]$ for the signals at the speakers for the n-th block.

- The 2x1 vector of phasors $X_m[n]$ of signals at microphones are given by:

$$X_m[n] = H_s{*}X_s+H_t{*}X_t[n] +W[n]$$

  - X_t – 4x1 vector of phasors for signals at speakers
  - X_s – phasor of signal from source (unknown)
  - H_t – 2x4 complex propagation matrix from speakers to mics (unknown).
  - H_s – 2x1 complex propagation matrix from source to mic (unknown)
  - W[n] – 2x1 complex vector of measurement noise (random).

Algorithm Flowchart



Algorithm Description

- The algorithm searches for the phasor that produces the lowest power signal at the microphones:
  - Compute power with most recently used phasor.
  - If power is lowest ever seen, record power and corresponding, best phasor.
  - Select a new phasor to try; add a small perturbation to best phasor.
  - Record phasor, in case it turns out to be better.
- State variables:
  - The algorithm relies on the following variables to be preserved between calls.
    - pwr: the best, i.e., lowest, power ever seen.
    - best: the phasor that produced the best power
    - last: the most recently used phasor.
  - State variables are updated in each iteration.

Summary and Conclusions

- Presented simple algorithm to adapt phasors used by canceller.
- By construction, the algorithm produces ever improving phasors.
- Room for Improvement:
  - Measurement noise throws off the algorithm – need averaging.
  - Fixed size perturbation will either produce slow convergence or poor cancellation.
    - Small perturbation: slow convergence
    - Larger perturbation: ineffective cancellation.