Physics-Based Analysis and Control of Human Snoring
Yaselly Sanchez¹ advised by Jinxiang Xi² & Haibo Dong¹

University of Virginia¹  California Baptist University²

MOTIVATION
◊ Snoring and Obstructive Sleep Apnea (OSA) affect about 25 million U.S. adults [1]
◊ Snoring: obstruction in either soft palate, pharynx, or tongue [2]
◊ OSA is caused by the partial or complete obstruction of the airway during sleep and may lead to chronic illness: [3]
- Hypertension
- Coronary Heart disease
- Congestive Heart Failure
- Stroke

Fig. 1: American adult population and sleep behavior [4]

OBJECTIVES
Using a high-fidelity simulation tool, the following will be understood and accomplished

Flow physics of human snoring with anatomically and dynamically accurate models
Structural and functional changes that affect snoring
Create surgical guidelines modifications to eliminate human snoring

VALIDATION OF CFD STUDY
MEDICAL IMAGE-BASED VALIDATION [5]

CFD Simulation
Validation

METHODOLOGY
PHYSIOLOGY: Magnetic Resonance Images (MRI) were used to create a scaled model of the

MODELING: Three different models were designed all ranging from at-risk OSA to chronic OSA

MODEL 1
MODEL 2
MODEL 3

At-Risk  Snoring  Transition  Sleep Apnea  Chronic

RECONSTRUCTION: Two different uvula movements were examined (kinematics 1 and 2), and seven pressure probes were placed strategically to examine real-life adult flow of 20L/min

RESULTS
VORTEX STRUCTURES: Increased vortex shedding in kinematics 2 model 1 (snoring) than in model 3 (sleep apnea)

SHEAR LAYER: The obstruction of the airway modulates the air flow and causes shear layers to grow

VELOCITY: Presence of reversed jets around the uvula in kinematics 2 cause flow to go in the opposite direction

FAST FOURIER TRANSFORM: Different harmonics and vibrations that correspond to sound generation at different stages of OSA were found

CONCLUSIONS
Geometry affects the vortex structures, shear forces, and velocity of the flow. Amplitudes in each model were quantified to monitor the progression of sleep apnea. Further research will include flow-structural interaction, different age groups and uvula shapes to then create surgical guidelines OSA treatment.

References:

In collaboration with Junshi Wang & Pan Han