as of March 2019

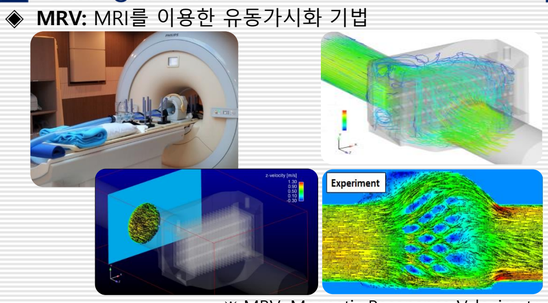
Current Research of MFL

Department of Mechanical Engineering, Hanyang University

Magnetic Resonance Velocimetry (MRV) I: Custom-made RF Coil

Background

◈ **MRV:** MRI를 이용한 유동가시화 기법



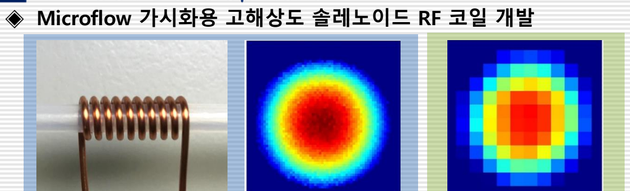
※ MRV: Magnetic Resonance Velocimetry

◈ 광학 기반 유동가시화 기법 대비 MRV의 장점

	측정영역	비침습	추적입자 첨가	불투명 유동	복잡한 유로형상	측정시간 (3D)	해상도
LDV	1점	O	O	X	X	오래 걸림	매우 높음
PIV, PTV	2D, 3D	O	O	X	X	보통	높음
X-ray PIV	2D	O	X	O	O	보통	낮음
초음파 PIV	2D	O	X	O	O	보통	낮음
MRV	**3D**	**O**	**X**	**O**	**O**	**짧음**	**중간**

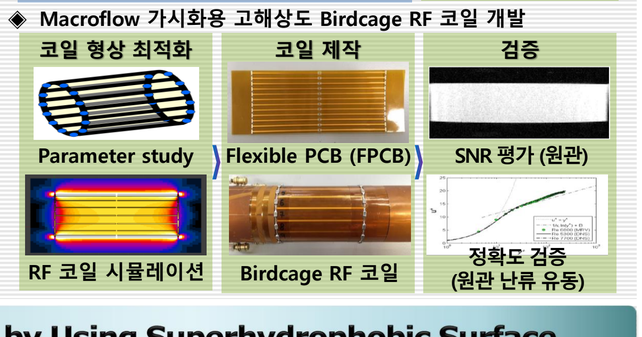
RF Coil Development

◈ **Microflow 가시화용 고해상도 솔레노이드 RF 코일 개발**



***Solenoid* RF coil** | ***Solenoid* RF coil measurements** | ***Conventional* RF coil measurements**

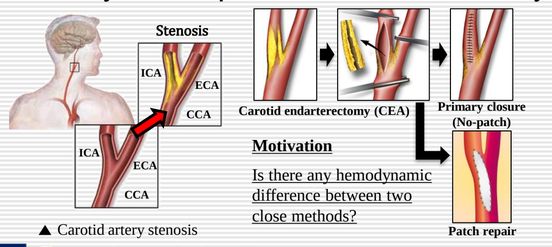
◈ **Macroflow 가시화용 고해상도 Birdcage RF 코일 개발**



Magnetic Resonance Velocimetry (MRV) II : Hemodynamics

Background

◈ **Hemodynamic comparison of carotid endarterectomy**

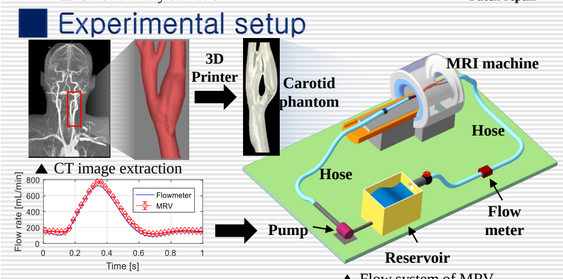


▲ Carotid artery stenosis

Motivation

Is there any hemodynamic difference between two close methods?

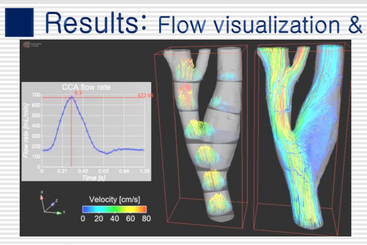
Experimental setup



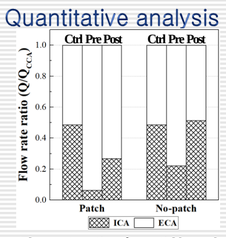
▲ CT image extraction

▲ Flow system of MRV

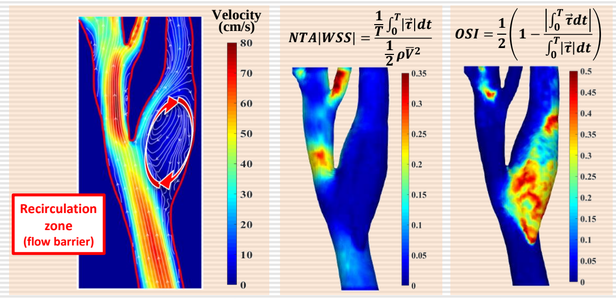
Results: Flow visualization & Quantitative analysis



▲ Flow visualization of internal carotid flow



▲ Flow rate ratio of carotid branches

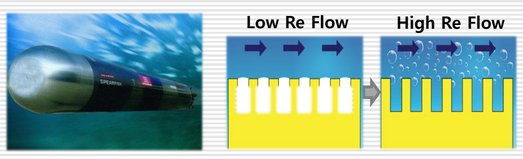


▲ Normalized Time Averaged Wall Shear Stress & Oscillatory Shear Index

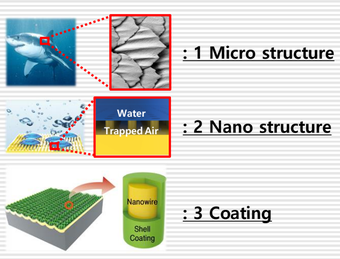
Skin-friction Drag Reduction(DR) by Using Superhydrophobic Surface

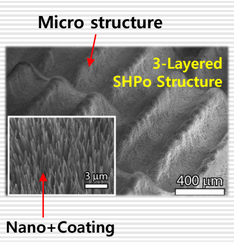
Background

◈ **Superhydrophobic surface : Drag reduction**
Turbulent flow breaks air-layer → Drag increase

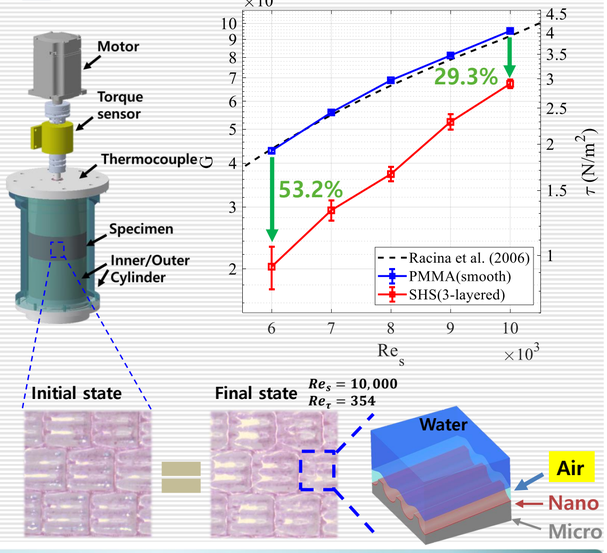


3-Layered Superhydrophobic Structure





Results

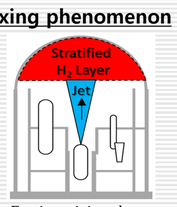


Erosion Mixing of Stratified Layer by Impinging Jet

Background

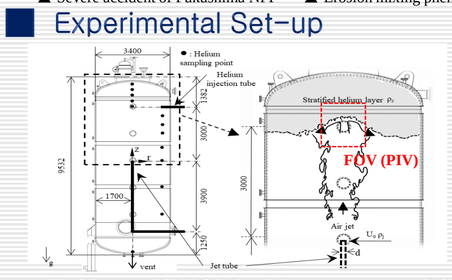
◈ **Severe accident & Erosion mixing phenomenon**

▲ Severe accident of Fukushima NPP



▲ Erosion mixing phenomenon

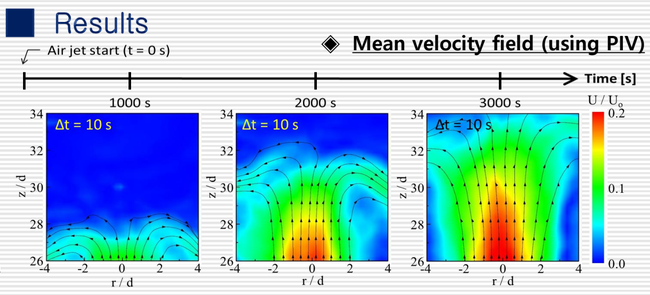
Experimental Set-up



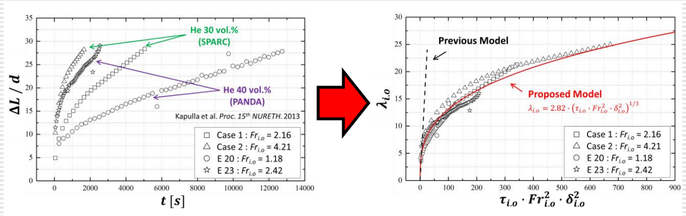
▲ The Schematic of SPARC facility & Jet impinging on stratified layer

Results

◈ **Mean velocity field (using PIV)**



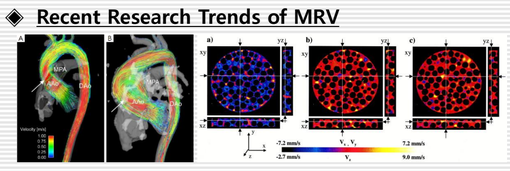
◈ **Validation of novel scaling law for interface displacement**



Divergence-free Smoothing for Noisy Wall-bounded Flow

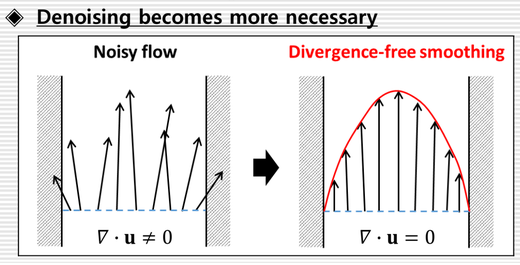
Background

◈ **Recent Research Trends of MRV**

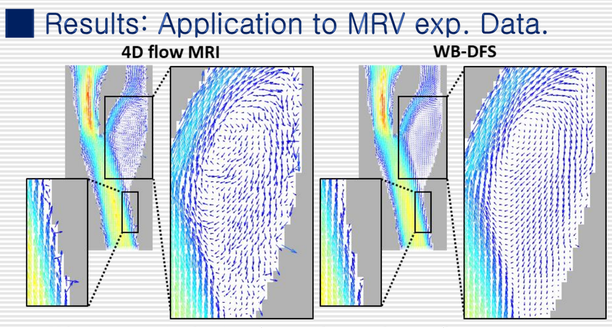


Hemodynamic parameter analysis (WSS,OSI) for clinical application
→ Accurate velocity measurements is very important near wall.
Undersampling/Compressed sensing to reduce acquisition time
→ With the cost of increasing noise.

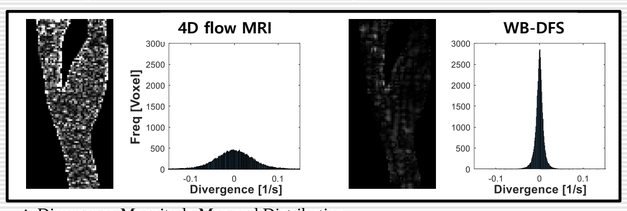
◈ **Denoising becomes more necessary**



Results: Application to MRV exp. Data.



▲ Velocity vector visualization of a carotid artery phantom flow



▲ Divergence Magnitude Map and Distribution

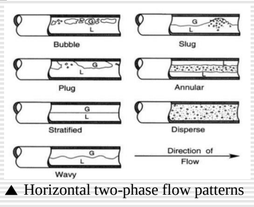
Two-phase Flow Pattern Classification Using Machine Learning

Background

◈ **Importance of two-phase flow**

Problem	Analysis
• Heat Transfer • Pressure Drop • Noise	• Void Fraction • Vapor Quality

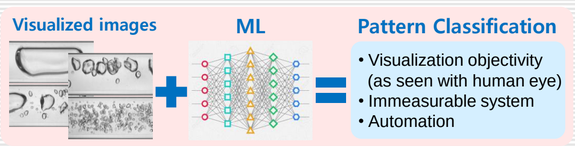
↳ depend on ***Flow Patterns***



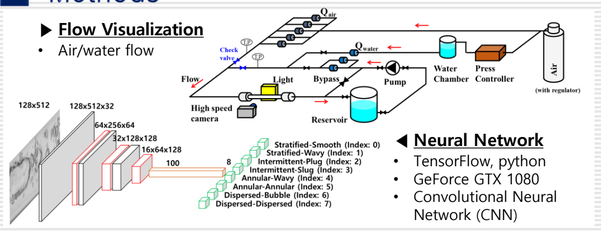
▲ Horizontal two-phase flow patterns

◈ **Machine learning (ML)**

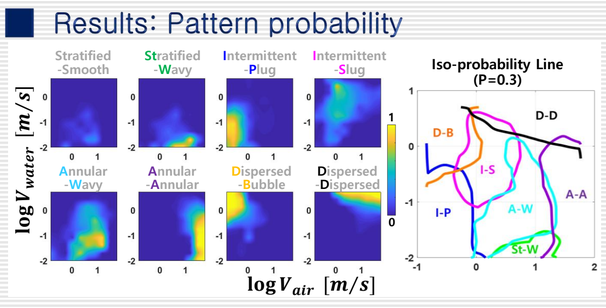
- Is a subset of an **artificial intelligence**
- has been used to identify the flow patterns with **measurable parameters** such as velocity, flowrate, void fraction, pressure and impedance signals, etc.



Methods



Results: Pattern probability

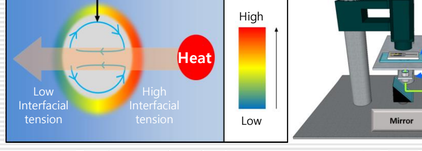


Vortex Induced Vibration (VIV) Simulation Using OpenFOAM

Background

◆ **Vortex induced vibration phenomenon is applied for energy harvesting technology. We are numerically investigating effect of cylinder geometry on energy harvesting efficiency.**

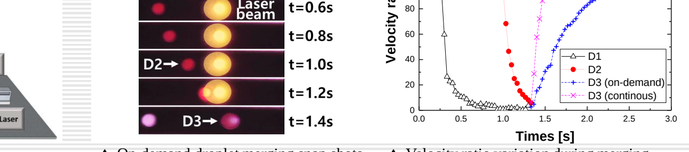
◈ **Karman Vortex Street(flow past a cylinder)**



◈ **Vortex Induced Vibration**

▲ Scheme of VIV system

Numerical Setup (pre-processing)



▲ Asymmetrically chamfered cylinder

▲ Grid for analysis

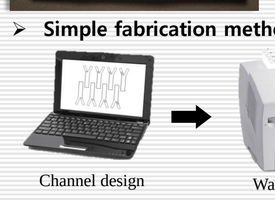
Results: Streamline & Phase portrait

▲ Stream line plot on z-vorticity contour

▲ Lift coefficient vs. cylinder displacement

Non-invasive Pressure Estimation from Given Velocity Field

Background

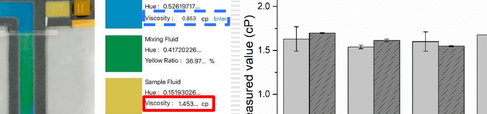


- **Pressure drop** across cardiovascular flow in blood vessel is a recognized clinical guide for cardiovascular diseases diagnosis.
- **Non-invasive pressure estimation** can be calculated from 4D flow MRI velocity field data.

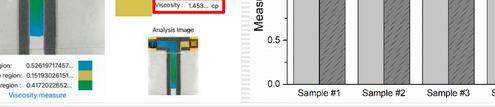
➢ **Non-invasive pressure estimation methods**

▲ 3D ODI ▲ WERP ▲ PPE

Results: Hagen-Poiseuille Flow



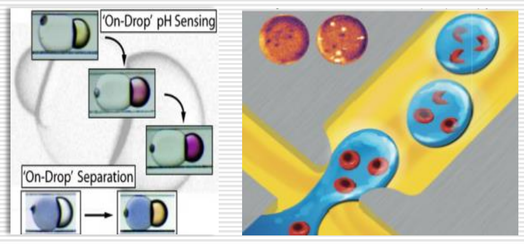
▲ Remodelling of Blood Vessel Phantom



▲ 3D velocity profile ▲ Noise-free ▲ 2% Noise

Droplet control using thermocapillary effects

Background

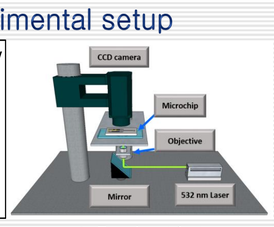


▲ pH sensing

▲ Red blood cell containing droplets

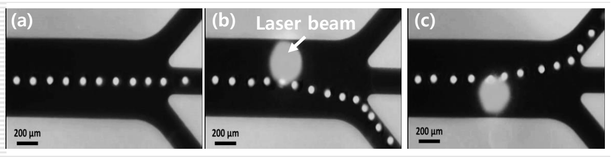
Principle & Experimental setup

▲ Droplet control mechanism



▲ Experimental setup

Results: Droplet trajectory control



▲ Without laser illumination ▲ With laser illumination (upper side) ▲ With laser illumination (downer side)

Results: Droplet merging control

▲ On-demand droplet merging snap shots ▲ Velocity ratio variation during merging

Paper-based Microfluidic Viscometer for Blood Plasma

Background : Paper-based Microfluidics

- **Paper** is a familiar material that is **cheap** and **easy to use**.
- **Blood plasma viscosity** is an important index for the diagnosis of various diseases

➢ **Simple fabrication method**

Channel design | Wax printing | Reflowing

Development of paper-based viscometer

➢ **Viscosity measurement by colorimetric analysis**

➢ **Facile measurements using a smartphone application**