Generating Various Flow Fields using Principal Component Analysis

Syuhei Sato[1] *Yoshinori Dobashi*[1,5,6] *Kei Iwasaki*[2,6] *Hiroyuki Ochiai*[3,5] *Tsuyoshi Yamamoto*[1] *Tomoyuki Nishita*[4,6]

[1]*Hokkaido University* [2]*Wakayama University* [3]*Kyushu University* [4]*Hiroshima Shudo University* [5]*JST CREST* [6]*UEI Research*

Laboratory of Information Media Environment

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Introduction

Similar fluid animations are required to create large scale fluid scenes.

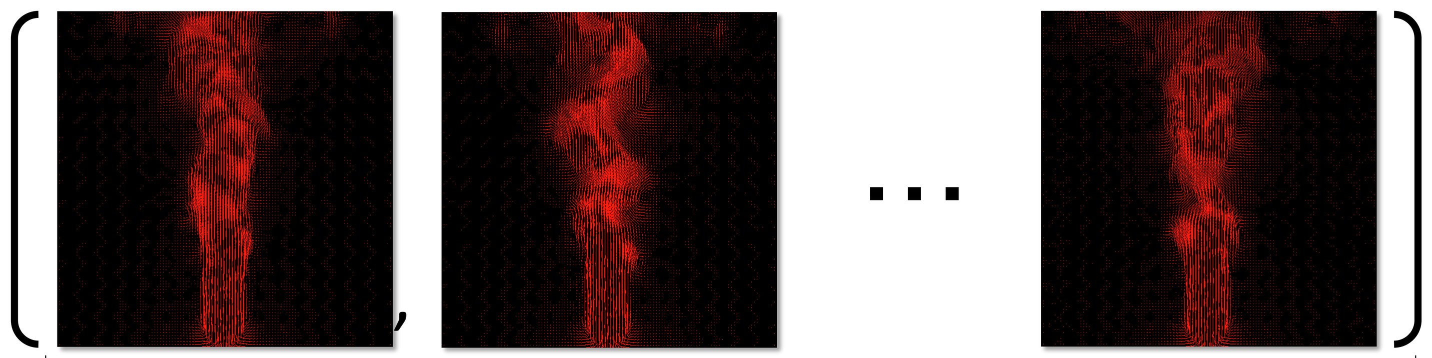
Problems in creating multiple animations:
- repeating fluid simulations many times with different parameters
- time-consuming task for adjusting parameters
- huge computational costs for fluid simulations

A method for efficiently creating various fluid animations

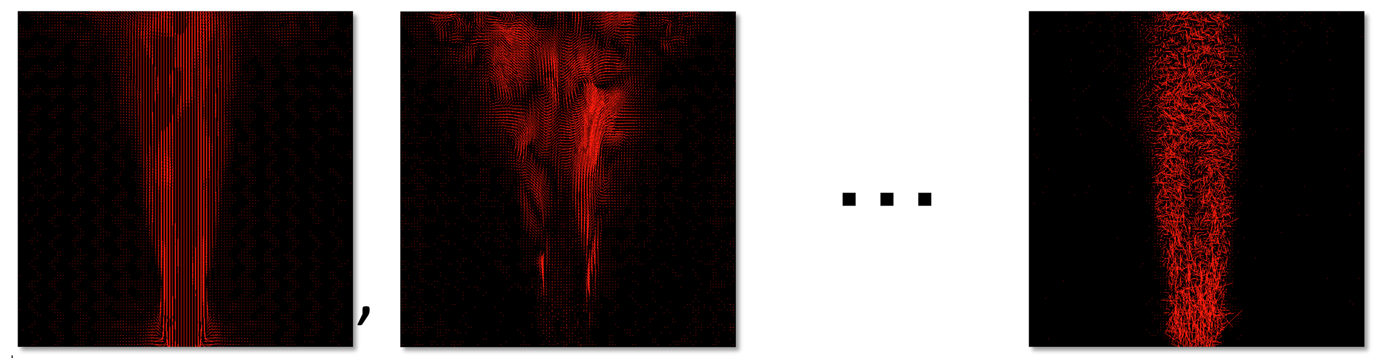
Our method can create various flow fields;
- from a single simulated dataset
- without executing fluid simulations
- by modulating PCA coefficients

Our method

- Computing principal components of input velocity fields



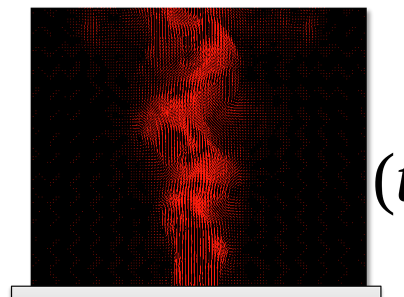
PCA



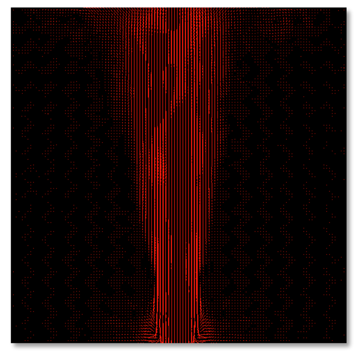
Input velocity fields ($\mathbf{v}(0), \mathbf{v}(1), \ldots \mathbf{v}(T)$) $T > N$ Principal components ($\mathbf{\Phi}_0, \mathbf{\Phi}_1, \ldots \mathbf{\Phi}_N$)

- Modulating coefficients of each principal component

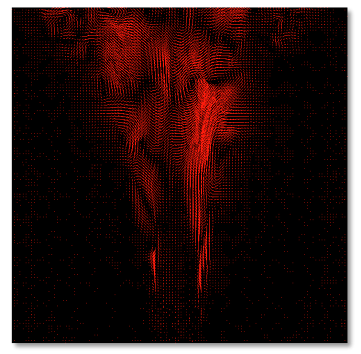
Flow fields are represented by a linear combination of principal components



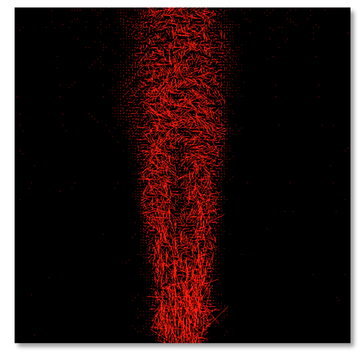
original (t) $=$ $w_0(t)$

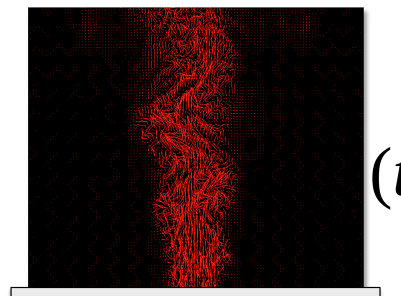


$+ \; w_1(t)$



$+ \cdots + \; w_N(t)$



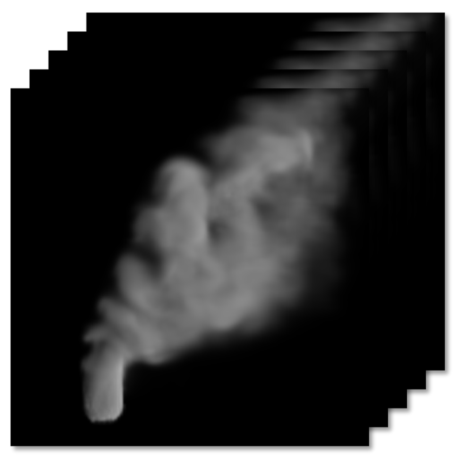


variation (t) $= 0.5 w_0(t) + 0.7 w_1(t) + \cdots + 2.0 w_N(t)$

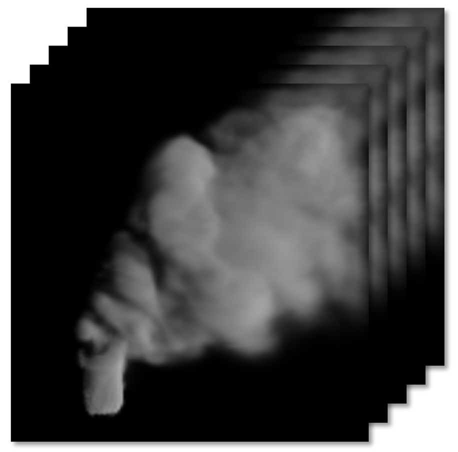
Principal components ($\mathbf{\Phi}_0, \mathbf{\Phi}_1, \ldots \mathbf{\Phi}_N$)

Results

Smoke examples

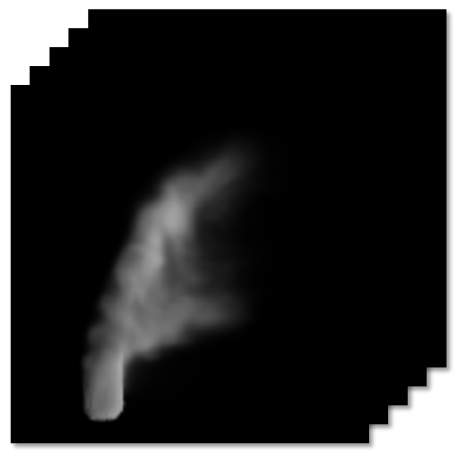


original



(a) increasing LOC

(b) increasing HOC



(c) decreasing LOC

(d) apply (b) and (c)

LOC : lower-order coefficients
HOC : higher-order coefficients

Fire examples

original

(a) increasing LOC

(b) increasing HOC

(c) decreasing LOC

(d) apply (b) and (c)

Limitations

- The results might violate momentum conservation more, if the degree of modulation is large.
- Our method cannot apply to fluids with drastically temporary-varying dominant flow direction.

Future work

Methods for:
- evaluating flow fields
- determining coefficients automatically
- extending to fluids with unsteady motions