

A Simple and General Model for Mobile Video Workload Generation

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Slides of this presentation are available at:

<http://www.cse.wustl.edu/~jain/wimax/video89.htm>

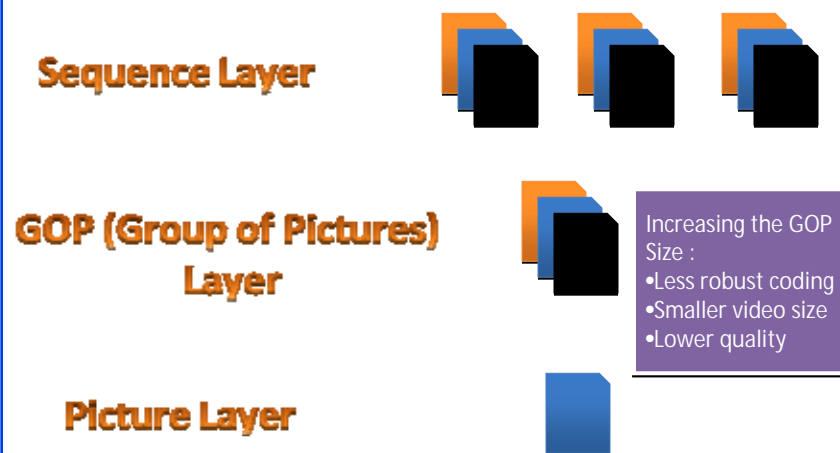


- Motivation
- MPEG Encoding
- Related Work
- Seasonal ARIMA
- SAM : Results
- Conclusion

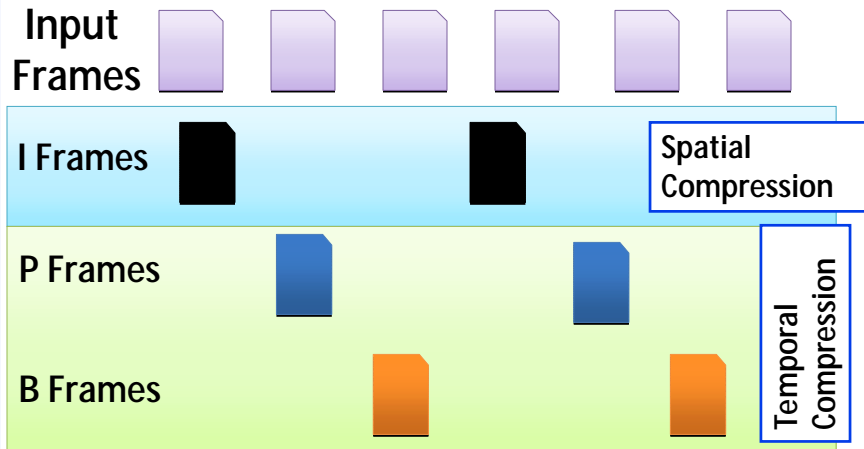
Motivation

- ❑ Video streaming is one of the fastest growing applications on the web
- ❑ 75 percent of the U.S. Internet users spend 3 – 3.5 hours/month watching streaming videos
 - [29% increase from last year]
- ❑ Advertisement revenues reached 1.37 billion dollars [1]
- ❑ Accurate video model to understand constraints of the network environment and its impact on video performance especially for time sensitive contents

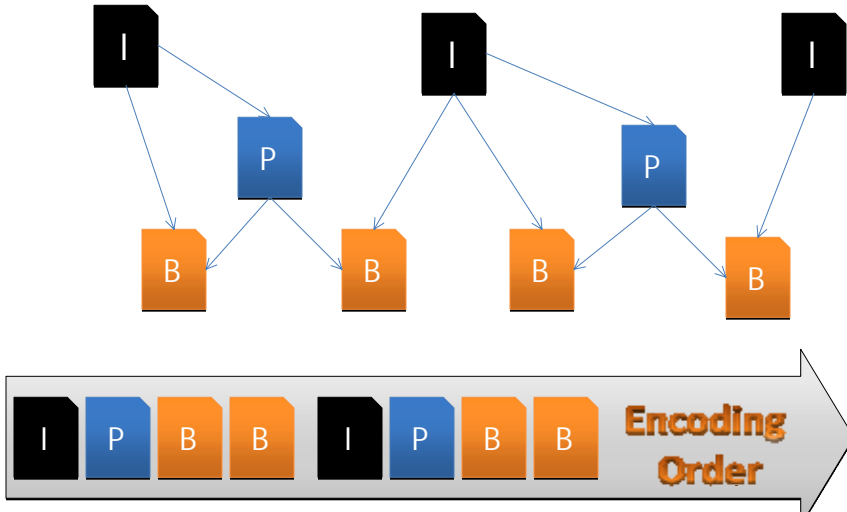
MPEG Layer Hierarchy



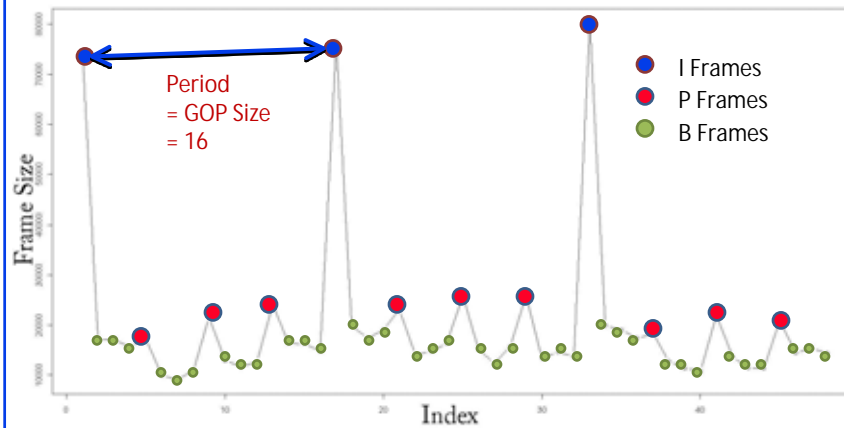
MPEG Encoding



Encoding and Transmission Order



Seasonality in MPEG Encoding



Previous and Related Work

- Markov chain models
- Separate models for I, P and B frames
- Considering “Epoch”: Group of scenes
- Time series models
- Wavelet models

Other considerations

- ❑ Solutions are movie specific
 - Require distribution history
 - Parameters tweaked for each individual movie
- ❑ “simple” approaches may require up to 9 parameters
- ❑ Most approaches are scene specific
- ❑ Complexity in the approach to reach satisfying results

Time Series Models

- ❑ Auto-regressive Models : AR

AR(1) Model:

$$y(t) = a_1 y(t-1) + w(t)$$

AR(p) Model:

$$y(t) = a_1 y(t-1) + a_2 y(t-2) + \dots + a_p y(t-p) + w(t)$$

The current value depends on the previous values

- ❑ Moving Average Models : MA

MA(1) Model:

$$y(t) = w(t) + b_1 w(t-1)$$

MA(q) Model:

$$y(t) = w(t) + b_1 w(t-1) + b_2 w(t-2) + \dots + b_q w(t-q)$$

The current value depends on the previous forecasting errors

Time Series Models (Cont)

- Autoregressive Moving Average Model: ARMA(p,q)

$$y(t) - a_1y(t-1) - \dots - a_p y(t-p) \\ = \\ w(t) + b_1w(t-1) + \dots + b_q w(t-1) + \dots + b_q w(t-q)$$

ARMA combines
Autoregressive
and Moving
Average
components

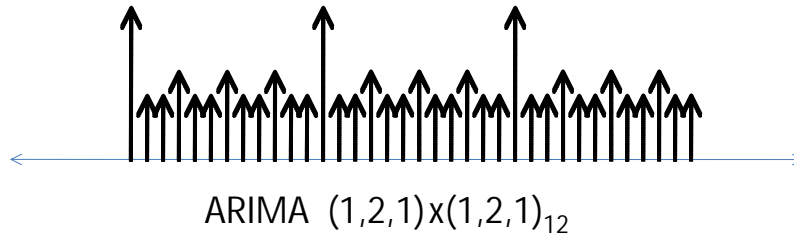
- Autoregressive Integrated Moving Average Model :
ARIMA (p,d,q)
 - ARIMA adds the differencing component with order d to obtain stationarity, here is the expression

$$y(t) - y(t-1) = w(t) + a_1[y(t-1) - y(t-2)] - b_1w(t-1)$$

Seasonal ARIMA

- Seasonal ARIMA models are used for data series that exhibit periodic behavior
- Seasonal ARIMA is described as:
 - ARIMA (p, d, q) × (P, D, Q)_s
 - P, D, Q are the same and operates across multiples of lag s (the number of periods in a season)

Seasonal ARIMA Example



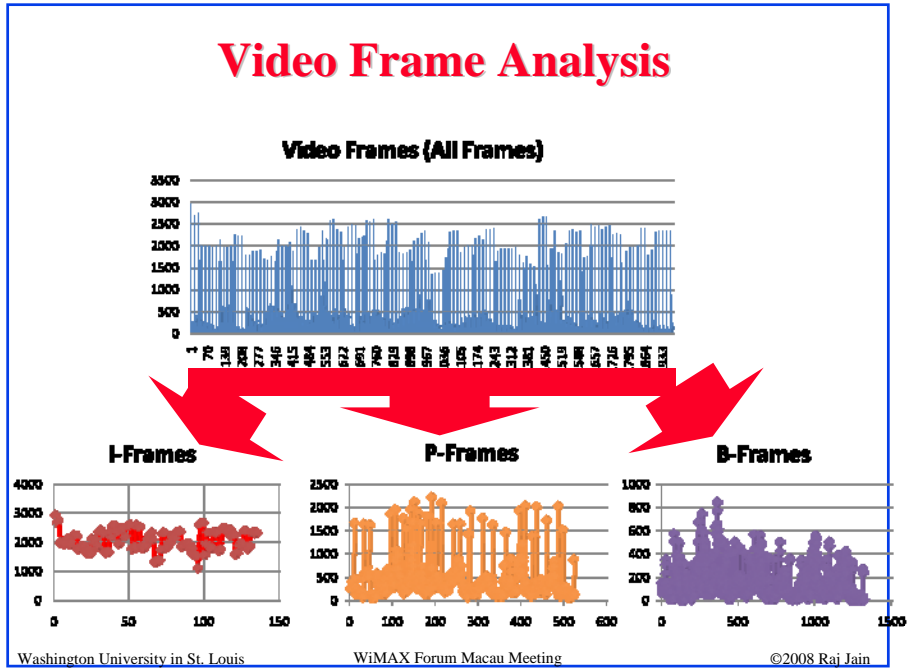
□ Example :

- ARIMA(1,2,1) x (1,0,1)₁₂
- Represents a series of period of 12

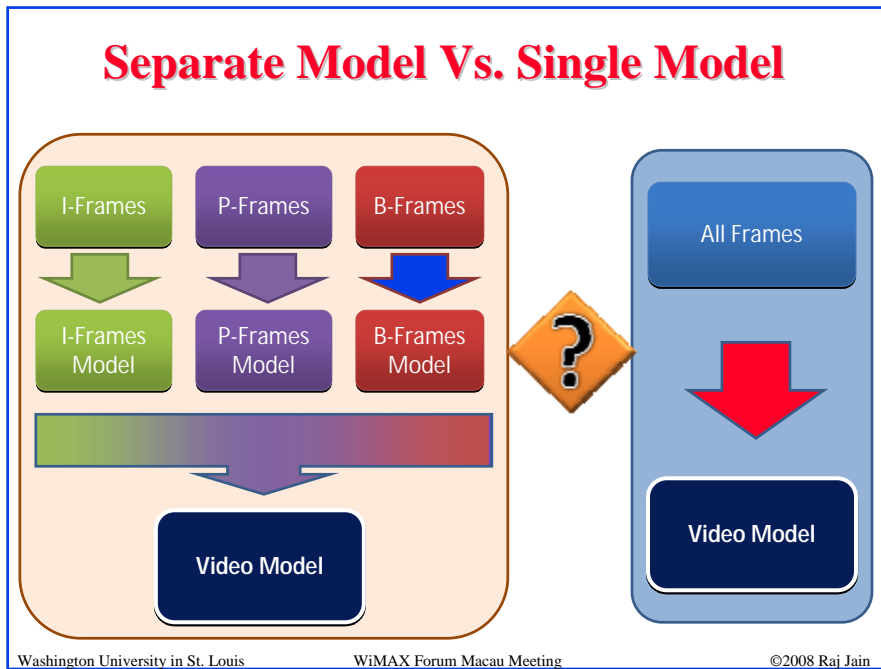
Preliminary Analysis: Short Scenes

- Simple TV ads
- Suitable video encoding
 - MPEG-4 Part 2
 - Advanced Simple Profile (ASP):
 - CIF (Common Intermediate Format)size
 - (352 × 288)
 - Frames rate 25fps
- Short scenes (6000 frames)

Video Frame Analysis



Separate Model Vs. Single Model



Results

Movie		All-Frames	Composite model (P-Frame, I-P-Frame, B-Frame)
Matrix I	Model	$[3, 0, 1] \times [1, 1, 1]^{12}$	$(0, 1, 3), [1, 1, 1], (3, 1, 6)$
	AIC (Akaike Info. Criterion)	128369.3	119775.3
LOTR I	Model	$[1, 0, 1] \times [1, 1, 1]^{12}$	$(0, 1, 5), [0, 1, 1], (2, 1, 2)$
	AIC (Akaike Info. Criterion)	125689.7	125270.9
LOTR II	Model	$[3, 0, 3] \times [1, 1, 1]^{12}$	$(0, 1, 3), [0, 1, 1], (1, 1, 2)$
	AIC (Akaike Info. Criterion)	127488.4	125278.9

- Though composite model is better, All Frames or single model is pretty close.
- Composite model requires more analysis work, and multiplexing
- AIC = goodness = accuracy and the number of the parameters

Simplified Seasonal ARIMA Model

Movie		All-Frames	Composite model (P-Frame, I-P-Frame, B-Frame)	General model
Matrix I	Model	$[3, 0, 1] \times [1, 1, 1]^{12}$	$(0, 1, 3), [1, 1, 1], (3, 1, 6)$	$[1, 0, 1] \times [1, 1, 1]^{12}$
	AIC (Akaike Info. Criterion)	128369.3	119775.3	120378.1
LOTR I	Model	$[1, 0, 1] \times [1, 1, 1]^{12}$	$(0, 1, 5), [0, 1, 1], (2, 1, 2)$	$[1, 0, 1] \times [1, 1, 1]^{12}$
	AIC (Akaike Info. Criterion)	125689.7	125270.9	125689.7
LOTR II	Model	$[3, 0, 3] \times [1, 1, 1]^{12}$	$(0, 1, 3), [0, 1, 1], (1, 1, 2)$	$[1, 0, 1] \times [1, 1, 1]^{12}$
	AIC (Akaike Info. Criterion)	127488.4	125278.9	127587

- Conclusion: ARIMA(1,0,1)(1,1,1)^G represents most of the movies that we have analyzed.**

Full Movie Analysis

- ❑ Full movie traces
- ❑ Matrix trilogy :
 - Each around 188 thousand frames
- ❑ LOTR (Lord of The Rings) trilogy :
 - Each around 266 thousand frames

Frame Size Statistics

Movie	Standard Deviation	Mean
LOTR 1	9594.778	9342.26
LOTR 2	11178.38	11481.00
LOTR 3	10794.25	11145.63
Matrix 1	7946.338	7348.922
Matrix 2	10687.00	9508.467
Matrix 3	12701.56	10522.08

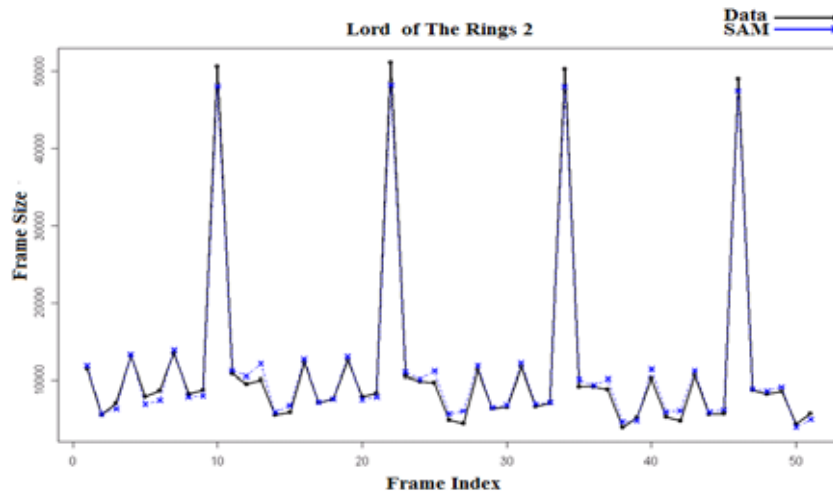
- ❑ Observation: Mean and Standard deviation vary significantly.

Models for Mobile Video

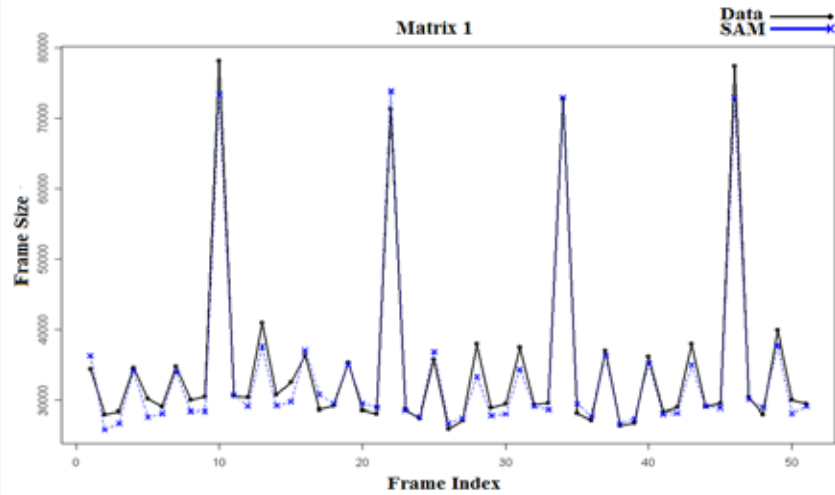
Movie	AIC (Optimal)	AIC (SAM)	Difference% ([S-O]/O)
LOTR 1	15209108	15214697	0.036%
LOTR 2	18195617	18220707	0.137%
LOTR 3	16495282	16515722	0.123%
Matrix 1	11222747	11227109	0.038%
Matrix 2	20321203	20361456	0.198%
Matrix 3	34489730	34764677	0.797%

☐ Observation: SAM is within 1% of the optimal model

Observed vs Predicted Frame Sizes

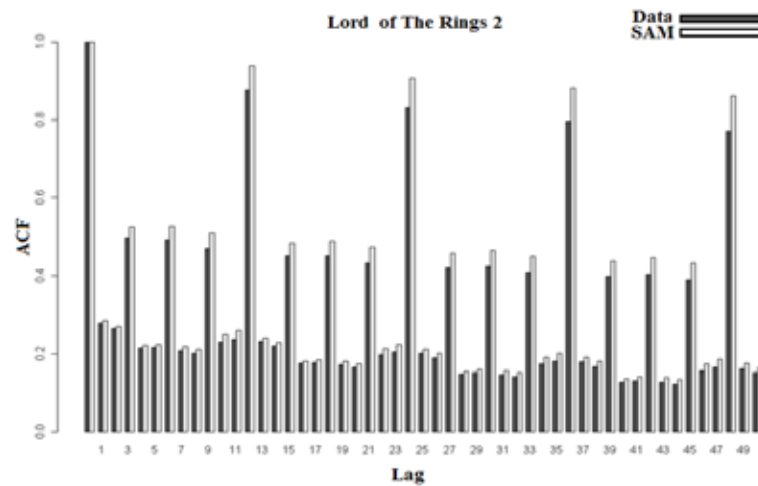


Observed vs Predicted Frame Sizes 2



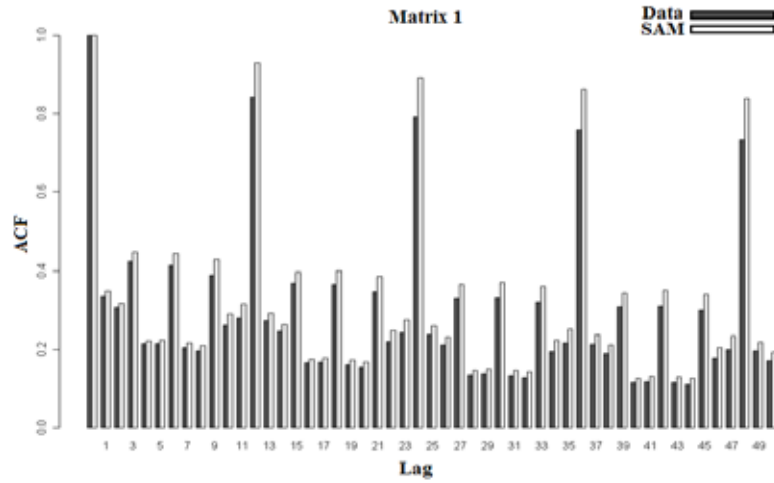
□ Observation: Good fit

Observed vs Predicted ACF



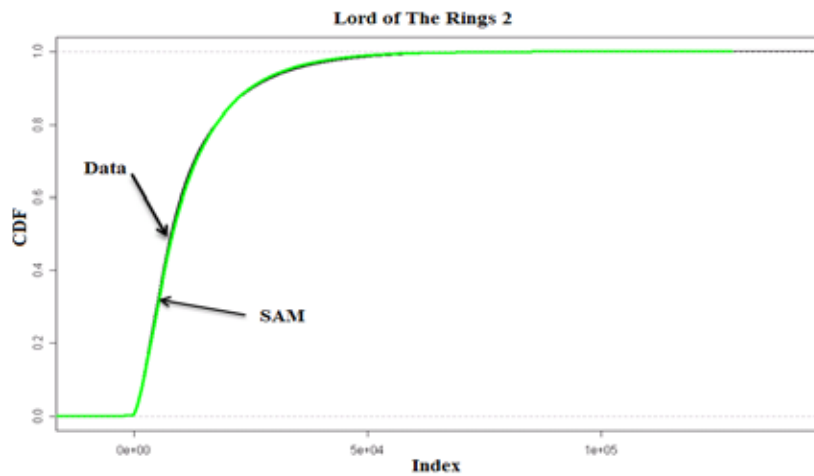
□ Observation: Good fit

Observed vs Predicted ACF 2



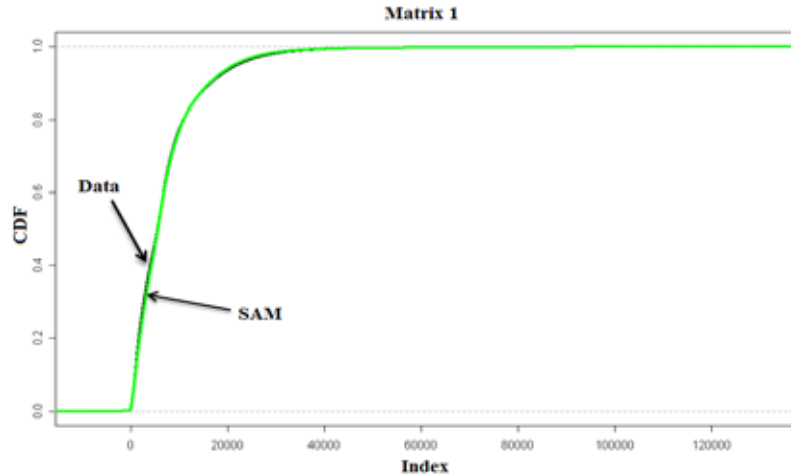
☐ Observation: Good fit

Observed vs Predicted CDF



☐ Observation: Good fit

Observed vs Predicted CDF 2



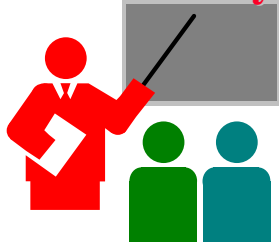
- Observation: Good fit
Single model is good. What about model parameters?

Model Parameters

Movie	AR	MA	SAR	SMA
LOTR 1	0.9262	-0.6911	0.2411	-0.8638
LOTR 2	0.9306	-0.6770	0.2715	-0.8610
LOTR 3	0.9322	-0.6818	0.2683	-0.8440
Matrix 1	0.9241	-0.6561	0.1602	-0.8050
Matrix 2	0.9382	-0.6809	0.2336	-0.8760
Matrix 3	0.9327	-0.6372	0.1002	-0.8951
Mean	0.93	-0.67	0.21	-0.86
[Min, Max]	[0.924, 0.938]	[-0.691, -0.637]	[0.1, 0.271]	[-0.895, -0.805]

- Observation: There is very little variation in parameters.

Summary



- IPB or composite model is better than All-Frames or a single model however the difference is small
- SAM model is a simple seasonal ARIMA model that is capable of representing different movies
- Movies models coefficients are quite close to each other, which suggest a unified model
- Will this model work with all movies from different genres ? → Future work

Reference

- Abdel-Karim Al-Tamimi, Raj Jain, Chakchai So-In, “SAM: A Simplified Seasonal ARIMA Model for Mobile Video over Wireless Broadband Networks,” Proc. IEEE International Symposium on Multimedia (ISM 2008), Berkeley, CA, December 15-17, 2008, http://www.cse.wustl.edu/~jain/papers/sam_ism.htm