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In this context, write an essay on the topic: **“Role of Difference Equations in the Analysis of Time Series”.**

Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data. Time series forecasting is the use of a model which contain difference equations to predict future values based on previously observed values. The theory of difference equations underlies all of the time-series methods.

Linear difference equations containing random component play an important role in the time series models, their solutions are closely related to the stationary conditions of time series models. The properties of these models often rely upon the attributes of the roots of these difference equations.

Higher order difference equations emerge quite naturally in economic analysis. The study of the behavior of ARMA(Autoregressive-moving-average model) processes and their ACFs(Autocorrelation function) is greatly enhanced by a knowledge of difference equations, simply because they are difference equations. By looking at the autocorrelation function (ACF) and partial autocorrelation (PACF) plots of the differenced series, you can tentatively identify the numbers of AR and MA terms that are needed. It useful in the study of the domain models and stochastic or random processes in general. The objective of evaluation of time series models is based on analysis of difference equations containing random components, in order to forecast the observed phenomena in the future. Difference equation is parametric stochastic process model that express the value of a variable as a function of its own lagged value and other variable. The trend and seasonal terms are both functions of time and the irregular term is a function of its own lagged value and of the stochastic variable *έt*.

For example, the random Walk Model, in its simplest from says that day-to-day changes in the price of a stock should have a mean value of zero. As we know, if it is known that a capital gain can be made by buying a share on day *t* and selling it for an expected profit the very next day, efficient speculation will drive up the current price. Similarly, no one will want to hold a stock if it is expected to depreciate. Formally, the model asserts that the price of a stock should evolve according to the stochastic difference equation

or

where *yt* = the price of a share of stock on day *t*, and *έt+1* = a random disturbance term that has an expected value of zero.

Now consider the more general stochastic difference equation

The random walk hypothesis requires the testable restriction: *α*0 = *α*1 = 0 which can only be implemented by using stochastic difference equation. Rejecting this restriction is equivalent to rejecting the theory. Given the information available in period *t*, the theory also requires that the mean of *έt*+1 be equal to zero; evidence that *έt*+1 is predictable invalidates the random walk hypothesis.

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**A.1.1 Introduction**

A randomized algorithm is a method that uses randomness as its logic. As a result, their outcomes do not depend only on their (external) inputs. When considering randomized algorithms, what we usually care about is its expected worst-case performance, which is average it takes on the worst input of the given size. These algorithms are usually simple and straightforward. These algorithms are regularly used in circumstances where no exact and fast algorithm is known. These algorithms are fast as making random choice within a specified range is a faster process and are typically used to diminish time complexity of the problem. For example, quick sort is a simple and efficient method of sorting and it this we random number to pick the pivot element.

**A.1.2 Advantages and drawbacks of randomized algorithm**

Advantages:

* Randomized algorithms are simple and easy to implement.
* Randomized algorithms are often easier to design and analyse.
* Randomized algorithms are often faster either from the worst-case asymptotic point of view or/and from the numerical implementations point of view as it produces optimum output with very high probability.
* Randomized algorithms use less memory hence they are space efficient.
* These kind of algorithms could help accelerate a brute force process by randomly sampling the input in order to obtain a solution that may not be totally ideal, but will be good sufficient for the specified purposes like Monte Carlo Algorithm which produces solution with a certain probability.

Drawbacks:

* They are unrealistic.
* Most of the tests are redundant.
* More time is spent on analysing results.
* The actual test results are random in the case of randomized software and random testing. Therefore, it is not possible to give an exact expected value.
* One cannot recreate the test if data is not recorded which was used for testing.

**A.1.3 Stance and Justification**

Randomness reduces time complexity as making random choice within a specified range is a faster process which makes the algorithm fast. Let’s take the example firefly algorithm(FA) to understand it better.

Fireflies are unisex so that one firefly will be attracted to other fireflies regardless of their sex. The attractiveness is proportional to the brightness, and they both decrease as their distance increases. Thus for any two flashing fireflies, the less bright one will move towards the brighter one. If there is no brighter one than a particular firefly, it will move randomly.

we can now define the variation of attractiveness β with the distance r by

β = β0e −γr2

where β0 is the attractiveness at r = 0.

Firefly algorithm has two inner loops when going through the population n, and one outer loop for iteration t. So the complexity at the extreme case is O(n2t).

If n is relatively large, it is possible to use one inner loop by ranking the attractiveness or brightness of all fireflies using sorting algorithms. In this case, the algorithm complexity of firefly algorithm will be O(ntlog(n)).

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**A1.1** Benefits and limitations of Source-Channel separation theorem :

It is currently time to join the outcomes from the discrete source coding theorem

furthermore, the channel capacity theorem. The discrete source coding theorem states

that the information Xn can be compressed to utilize subjectively near H∞(X) bits per

coded source symbol and the channel capacity theorem expresses that subjectively close

to C bits per channel use can be dependably transmitted over a given channel. Knowing these different outcomes the inquiry regarding how to design the encoder/decoder

in a system which needs to do both source and channel coding

emerges. Since the discrete source coding theorem just relies upon the statistical

properties of the source and the channel coding theorem just relies upon the statistical properties of the channel one may expect that a different design of source

furthermore, channel codes is comparable to some other strategy. Things being what they are, for stationary

sources a source– channel code exist when H∞(X) < C with the end goal that

the error probability amid transmission can be made subjective little. The converse, H∞(X) > C, infers that the error probability is limited far from zero

what's more, it is beyond the realm of imagination to expect to accomplish self-assertive little error probability. The situation when

H∞(X) = C is left unsolved and will rely upon the source insights just as

the channel properties.

For non stationary sources the source– channel partition coding theorem takes an other shape and we have to utilize ideas like "entirely commanding" and "control."

In view of these hypothetical outcomes it might show up as though source and channel codes

could be designed independently. Notwithstanding, this is just valid under the presumptions

legitimate when inferring the outcomes in and . One of these presumptions is the

utilization of boundlessly long codes, for example n → ∞. By and by this isn't possible, particularly when managing ongoing applications like video gushing or VoIP.

Source and channel coders are generally actualized successively and autonomously dependent on Shannon's outstanding partition hypothesis. Be that as it may, handy correspondence systems are compelled by intricacy and inertness. Subsequently, the partition coding guideline does not hold even hypothetically in some down to earth correspondence systems. Going for the constraint of the Shannon partition hypothesis in useful applications, numerous scientists have concentrated on the investigation of joint source-channel coding/decoding (JSCC/JSCD) systems. Through mutually enhanced source and channel parameters, they have accomplished a critical number of essential outcomes for ideal transmission execution.

**A1.2** Significance and applications of JSCC :

As of now, JSCC/JSCD methods are testing research subjects, with extraordinary hypothetical essentialness and application prospects. On the encoder side, the channel coder is constrained by the source hugeness data (SSI) from the source coder, which enhances the general encoding proficiency through joint source-channel coding. On the decoder side, the channel decoder uses the source an earlier data (SAI) from the encoder side and the channel state data (CSI) acquired from the channel estimator, to do the joint source-channel decoding. Through the dreary and iterative estimation and modification of the decoder dependability data (DRI) and the a data (API) between the channel decoder and the source decoder, a base joint decoding error proportion is accomplished. Existing joint source-channel streamlined design can be isolated into three classes.

The first is "Joint source-channel coding (JSCC)", which more often than not centers around the streamlined design of source coding and channel coding on the encoder side.

The second is "Joint source-channel decoding (JSCD)". It uses an earlier data (SAI) for bit-level encoding/decoding, which is predominantly for settled length encoding (FLC, for example, codebook-energized straight expectation (CELP). The benefit of the FLC lies in its basic usage and low multifaceted nature. Be that as it may, the pressure isn't as proficient.

The third is "Variable-length JSCC with variable-length JSCD". In light of the joint trellis, a symbol-level a post probability (APP) decoding calculation is additionally determined, which prompts a joint iterative decoding approach with symbol-level delicate yields. The exploratory outcomes demonstrate that the joint source-channel encoding/decoding plan has gotten preferred execution over existing joint iterative decoding dependent on the bit-level super trellis.

**A1.3** Conclusion  **:**

The gathering purpose of the two primary parts of the Shannon hypothesis is the joint source-channel coding theorem. This theorem has two sections: an immediate part and a converse part. It pursues that either dependable transmission is conceivable by isolated source-channel coding or it is absurd in any way. This is the motivation behind why the joint source-channel coding theorem is regularly alluded to as the partition theorem. We portray those channels for which the established explanation of the partition theorem holds for each source. We likewise portray those sources for which the partition theorem holds for each channel. An end to be drawn from our outcomes is that when managing non stationary probabilistic models, care ought to be practiced before applying the division theorem.