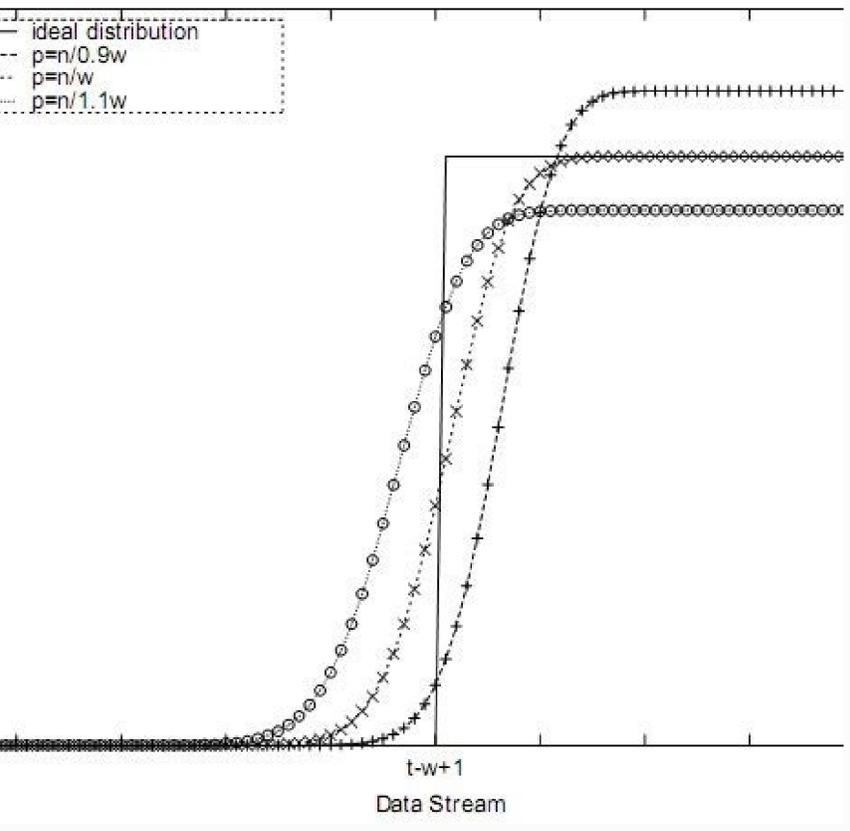I'm not robot

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Data Stream

New Sampling-Based Summary Statistics
for Improving Approximate Query Answers

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Abstract

In large data recording and warehousing environments, it is often advantageous to provide fast, approximate answers to queries, whenever possible. Before DBMSs providing highly-accurate approximate answers can become a reality, many new techniques for summarizing data and for estimating answers from summarized data must be developed. This paper introduces two new sampling-based summary statistics, concise samples and counting samples, and presents new techniques for their fast incremental maintenance regardless of the data distribution. We quantify their advantages over standard sample views in terms of the number of additional sample points for the same view size, and hence in providing more accurate query answers. Finally, we consider their application to providing fast approximate answers to hot list queries. Our algorithms maintain their accuracy in the presence of ongoing insertions to the data warehouse.
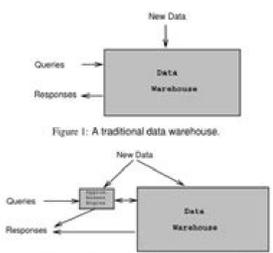
1 Introduction

In large data recording and warehousing environments, it is often advantageous to provide fast, approximate answers to queries. The goal is to provide an estimated response in orders of magnitude less time than the time to compute an exact answer, by avoiding or minimizing the number of accesses to the base data.

In a traditional data warehouse set-up, depicted in Figure 1, each query is answered exactly using the data warehouse. We consider instead the set-up depicted in Figure 2, for providing very fast approximate answers to queries. In this set-up, new data being loaded into the data warehouse is also observed by an approximate answer engine. This engine maintains various summary statistics, which we denote *synopsis data structures* or *synopses* [GM97]. Queries are sent to the approximate answer engine. Whenever possible, the engine uses its synopses to promptly return a query response, consisting of an approximate answer and an accuracy measure (e.g., a 95% confidence interval for numerical answers). The user can then decide whether or not to have an exact answer computed from the base data, based on the user's desire for the exact answer and the estimated time for computing an exact answer as determined by the query optimizer and/or the approximate answer

New Data

Queries → | Data Warehouse |
Responses ←

Figure 1: A traditional data warehouse.

New Data

Queries →
Responses ← | Data Warehouse |

Figure 2: Data warehouse set-up for providing approximate query answers.

engine.[1] There are a number of scenarios for which a user may prefer an approximate answer in a few seconds over an exact answer that requires tens of minutes or more to compute, e.g., during a drill down query sequence in data mining [GM95, HHW97]. Moreover, as discussed by Faloutsos *et al.* [FFS97], sometimes the base data is remote and currently unavailable, so that an exact answer is not an option, until the data again becomes available.

Techniques for fast approximate answers can also be used in a more traditional role within the query optimizer to estimate plan costs, again with very fast response time.

The state-of-the-art in approximate query answers (e.g., [VL93, HHW97, BDF+97]) is quite limited in its speed, scope and accuracy. Before DBMSs providing highly-accurate approximate answers can become a reality, many new techniques for summarizing data and for estimating answers from summarized data must be developed. The goal is to develop effective synopses that capture important information about the data in a concise representation. The important features of the data are determined by the types of queries for which approximate answers are a desirable option. For example, it has been shown that for providing approximate answers

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[1] This differs from the *online aggregation* approach in [HHW97], in which the base data is scanned and the approximate answer is updated as the scan proceeds.

TABLE B.35 (cont.) TEN THOUSAND RANDOM DIGITS

	00-04	05-09	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49

The table below contains results based on a class experiment with M&M's. Use this data to answer the questions that follow

Color	Avg Class Estimate	Percentage based on Class Estimate	Per M&M's Official
red	7	12%	13%
orange	15	25%	20%
yellow	7	12%	14%
green	9	15%	16%
blue	14	24%	24%
brown	7	12%	13%
total	59	100%	100%

Let X = the number of orange M&M's selected

X ~ Binomial (n, π)

We are interested in the number of orange M&M's selected from a sample of ten. Use the "Per M&M's Official" column to find the probability of selecting an orange.

the size of a U.S. farm in 1940 the average size of a U.S. farm, in acres N (174, 55 38) 168.0, 180.0 -> Determine which of the following are true and which are false. N (36, 10 16) 1 34.31 -> The distribution of income in some Third World countries is considered wedge shaped (many very poor people, very few middle income people, and even fewer wealthy people). MORE FROM SMARTER.COM The Central Limit Theorem The sampling distribution is a theoretical distribution. The Central Limit Theorem answers the question: from what distribution did a sample mean come? Parameter Population distribution Sample Sampling distribution of 's Mean μ Standard deviation σ The practical significance of The Central Limit Theorem is that now we can compute probabilities for drawing a sample mean, , in just the same way as we did for drawing specific observations, X's, when we knew the population mean and mean standard deviation and that the population data were normally distributed.. Find the 80th percentile of the distribution of the average of 49 fly balls. If there is variation in the items to be sampled, there will be variation in the samples. In words, X = _____ In words, = _____ ~ _____ (____,____) How is it possible for the standard deviation to be greater than the average? Simple shades and blinds carry the streamlined look throughout the room. Top a shade with a printed valance or swag to give the window dimension. When the sample size is large, the standard deviation of is approximately the same as the standard deviation of X. The mean of a sampling distribution of the means is approximately the mean of the data distribution. In words, X = _____ In words, = _____ ~ _____ (____,____) Would you be surprised if the 36 taxpayers finished their Form 1040s in an average of more than 12 hours? For some products, sampling would require destroying them, called destructive sampling. Suppose we randomly pick five albums from the collection. There are many options for window design, but shopping for window treatments doesn't have to be a daunting task. In words, X = _____ In words, = _____ ~ _____ (____,____) The IQR for is from _____ acres to _____ acres. In words, X = _____ X = _____ In words, = _____ ~ _____ (____,____) Find the first quartile for the average song length. The graph is purposefully drawn all squiggly to show that it does not matter just how odd ball it really is. Let the average of the 49 races. Graph the situation, and shade in the area to be determined. The distribution is unknown. Central Limit Theorem Given a random variable with known mean μ and known standard deviation, σ, we are sampling with size n, and we are interested in two new RVs: the sample mean, . Each observation on this distribution is a sample mean. The horizontal axis in the bottom panel is labeled 's. If the size (n) of the sample is sufficiently large, then ~ N(μ,). Mathematically, the E(x) symbol read the "expected value of x". X = the yearly income of someone in a third world country the average salary from samples of 1,000 residents of a third world country ~ N Very wide differences in data values can have averages smaller than standard deviations. Part a is exponential and part b is normal. Let = average percent of fat calories. You just need a basic understanding of the available options and have a plan for the room's design.Learn the LingoWhen you're shopping for window treatments, it helps to know the terms used to classify and describe them. For example, if the window casings look a bit worn and you don't have time to replace them, you may want to opt for blinds or shades mounted on the outside of the window or pair a shade with curtains to disguise the casing.Pick a StyleThe final consideration when shopping for window treatments is the style of the room. N Yes. Suppose we randomly survey 38 farmers from 1940. The standardizing formula has to be amended to recognize that the mean and standard deviation of the sampling distribution, sometimes, called the standard error of the mean, are different from those of the population distribution, but otherwise nothing has changed. The genius of thinking this way is that it recognizes that when we sample we are creating an observation and that observation must come from some particular distribution. According to the Central Limit Theorem, the larger the sample, the closer the sampling distribution of the means becomes normal. We are interested in the average cost of gasoline for the 16 gas stations. This recognition that any sample we draw is really only one from a distribution of samples provides us with what is probably the single most important theorem is statistics: the Central Limit Theorem. Explain why or why not in complete sentences. Of the 75 million possible samples, then, which one did you get? Outside mount refers to a window treatment attached to the wall surrounding the window. The curve never touches the x-axis. If six are in the sample, the number of possible samples increases to just more than one billion. The length of a song, in minutes, in the collection U(2, 3.5) the average length, in minutes, of the songs from a sample of five albums from the collection N(2.75, 0.066) 2.74 minutes 0.03 minutes In 1940 the average size of a U.S. farm was 174 acres. Shade the region corresponding to the probability. Inspect the window casing. Find the probability. If this is discovered, then we can treat a sample mean just like any other observation and calculate probabilities about what values it might take on. Changing the window treatments in a room is an easy way to update the look of the room without completely redecorating it. In words, X = _____ X = _____ In words, = _____ ~ _____ (____,____) Find the probability that an individual had between ?0.80 and ?1.00. Traditional rooms feel warm and inviting. Work from left to right and top to bottom. All these sample means were calculated from individual samples with the same sample size. They add splashes of color or tie together all the pieces of furniture and accessories in the space to create a cohesive look. Suppose we pick a country with a wedge shaped distribution. The new standardizing formula is Notice that in the first formula has been changed to simply μ in the second version. These are the individual observations of the population. On the other end of the decorating spectrum, cottage style has a casual, cozy feel. Frame windows with curtains in a bold color to add contrast to the room. One such example is measuring the ability of a metal to withstand saltwater corrosion for parts on ocean going vessels. Note the number of windows, their basic shape and how closely they're grouped together. The Central Limit Theorem for Sample Means: ~ N The Mean Central Limit Theorem for Sample Means z-score Standard Error of the Mean (Standard Deviation ()): Finite Population Correction Factor for the sampling distribution of means: Finite Population Correction Factor for the sampling distribution of proportions: Previously, the De Anza statistics students estimated that the amount of change daytime statistics students carry is exponentially distributed with a mean of ?0.88. Let the average salary be ? 2,000 per year with a standard deviation of ?8,000. This is also a practical way to familiarize yourself with the available options for your windows so you can narrow your choices. Sixteen gas stations from the Bay Area are randomly chosen. Notice that the horizontal axis in the bottom panel is labeled X. There are a total of 43 songs on the five albums. Without the Central Limit Theorem it would be impossible to proceed to inferential statistics from simple probability theory. This is the unknown distribution of the population values. We have effectively moved from the world of statistics where we know only what we have from the sample, to the world of probability where we know the distribution from which the sample mean came and the parameters of that distribution. Remember, we will never know what this distribution looks like, or its mean or standard deviation for that matter. Trade blinds for drapes to add softness to the room, or swap heavy curtains for shades to lighten the space. mean length of time for a sample of 36 taxpayers to complete IRS form 1040, in hours. length of time for an individual to complete IRS form 1040, in hours. Sampling thus raises an important question; just which sample was drawn. Solid color curtains may provide an interesting contrast to the rest of the room and add a touch of softness. Of course, no one would ever actually take all of these samples, but if they did this is how they would look. ~ _____ (____,____) Find the probability that the runner will average between 142 and 146 minutes in these 49 marathons. No. I would not be totally surprised because the probability is 0.2312 Suppose that a category of world-class runners are known to run a marathon (26 miles) in an average of 145 minutes with a standard deviation of 14 minutes. The distribution to use for the average cost of gasoline for the 16 gas stations is: ~ N(4.59, 0.10) ~ N ~ N ~ N Average a number that describes the central tendency of the data; there are a number of specialized averages, including the arithmetic mean, weighted mean, median, mode, and geometric mean. Inside mount means the window treatment hangs inside the window casing. The standard deviation of the distribution of the sample means, , is called the standard error of the mean. Sketch the graph. In its most basic form, the Central Limit Theorem states that regardless of the underlying probability density function of the population data, the theoretical distribution of the means of samples from the population will be normally distributed. Solid color drapes and wood shutters work well in these rooms because they don't detract from the rest of the decor.CC0/PIRO4D/Pixabay Modern rooms have clean lines and feature a minimalist approach to decorating. Let us assume that the standard deviation is two hours. If the size (n) of the sample is sufficiently large, then the distribution of the sample means will approximate a normal distributions regardless of the shape of the population. X = amount of change students carry X ~ E(0.88, 0.88) = average amount of change carried by a sample of 25 students. P(2000 < < 2100) = 0.1537 P(2100 < < 2200) = 0.1317 Which of the following is NOT TRUE about the distribution for averages? Find the first quartile for the average percent of fat calories. When the sample size is large, is approximately normally distributed. Suppose we randomly sample 36 taxpayers. The distribution of the sample mean will have higher probabilities closer to the population mean. (Figure) graphically displays this very important proposition. Explain why there is a difference in part e and part f. Suppose that the distribution of fly balls hit to the outfield (in baseball) is normally distributed with a mean of 250 feet and a standard deviation of 50 feet. Standard Error of the Mean the standard deviation of the distribution of the sample means, or . Shutters add architectural detail that contrasts beautifully with casual furnishings. You should get three measurements for each dimension (left, center and right for the width and top, middle and bottom for the length and depth).This information will help you narrow your search. At the same time, they provide privacy for you and your family and help you control the amount of light that enters your home. I would be surprised, because the probability is almost 0. If = average distance in feet for 49 fly balls, then ~ _____ (____,____) What is the probability that the 49 balls traveled an average of less than 240 feet? Find the 80th percentile for the average of these 49 marathons. Suppose that 16 individuals are randomly chosen. This was stated in (Figure) above. The area under the curve is one. Start with the basics and learn the difference between blinds, shades, shutters and valances.CC0/mploscar/Pixabay Although some people use the terms interchangeably, they refer to specific types of window treatments. Each sample mean is then treated like a single observation of this new distribution, the sampling distribution. N (145, 14 49) 0.6247 146.68 145 minutes -> The length of songs in a collector's iTunes album collection is uniformly distributed from two to 3.5 minutes. Even if the sample were randomly drawn, there are theoretically an almost infinite number of samples. The percent of fat calories that a person in America consumes each day is normally distributed with a mean of about 36 and a standard deviation of about ten. The time and expense of checking every invoice to determine its validity or every shipment to see if it contains all the items may well exceed the cost of errors in billing or shipping. What you put over the windows may complement or contrast with the furniture and colors. CC0/Pexels/Pixabay The Finishing Touch to a RoomWindow treatments are a decorative and functional part of a room. In these rooms you see wood accents, plush furniture and decorative items like baskets, plants and wall hangings that catch your eye. Blinds and shutters are typically made from sturdy materials like wood or metal and have slats that open and close. The Central Limit Theorem goes even further and tells us the mean and standard deviation of this theoretical distribution. Would you be surprised if one taxpayer finished his or her Form 1040 in more than 12 hours? This formula will be used in the next unit to provide estimates of the unknown population parameter μ. We randomly sample 49 fly balls. In a complete sentence, explain why. Suppose that we randomly pick 25 daytime statistics students. Sheer curtains over the windows enhance the light and airy ambience of the room, especially if you live in an area with plenty of outdoor breezes. The curve is skewed to the right. The standard deviation of the sampling distribution of the means will decrease making it approximately the same as the standard deviation of X as the sample size increases. Shades and valances are pieces of fabric. Graph the situation and shade in the area to be determined. The reason is that mathematically it can be shown that the expected value of is equal to μ. Unless you're buying custom-made window treatments, you have to find pieces that actually fit your window. True. Find the median of the average running times. ~ N(0.88, 0.176) 0.0819 0.1882 The distributions are different. The mean, median, and mode and are equal. In essence, this says that the mean of a sample should be treated like an observation drawn from a normal distribution. Grab a steel tape measure and paper to record notes. The Central Limit Theorem only holds if the sample size is "large enough" which has been shown to be only 30 observations or more. This is the

distribution called the sampling distribution of the means. Then, in complete sentences, justify your answers. Hardware may refer to the brackets and supports that hold the window treatment in place or decorative pieces like finials at the end of curtain rods.Get to Know Your WindowsBefore you start shopping for window treatments, take a good look at the spot you want to dress. ~ _____(_____, _____) For the group of 16, find the probability that the average percent of fat calories consumed is more than five. The reasons that one samples a population are obvious. The theoretical sampling distribution contains all of the sample mean values from all the possible samples that could have been taken from the population. Shades roll up and down over the entire window, but valances are just decorative pieces at the top.Other words that come in handy are installation terms. Consider 49 of the races. We randomly survey 1,000 residents of that country. You also want to find window treatments that enhance the window. One could draw an "unlucky" sample and make very wrong conclusions concerning the population. Why is it more likely that the average of the 1,000 residents will be from ?2,000 to ?2,100 than from ?2,100 to ?2,200? Scale the horizontal axis for . And the Central Limit Theorem says that they will be normally distributed. The mean of the sample means will equal the population mean. When the sample size is large, the mean of is approximately equal to the mean of X. The IQR(interquartile range) for the average song length is from _____−_____. Find the probability that the average of the 25 students was between ?0.80 and ?1.00. N (250, 50 49) 0.0808 256.01 feet −> According to the Internal Revenue Service, the average length of time for an individual to complete (keep records for, learn, prepare, copy, assemble, and send) IRS Form 1040 is 10.53 hours (without any attached schedules). d −> The cost of unleaded gasoline in the Bay Area once followed an unknown distribution with a mean of ?4.59 and a standard deviation of ?0.10. It is created by taking many many samples of size n from a population. Let's say that the standard deviation was 55 acres. Locate the window hardware.Then it's time to measure the windows' length, width and depth. With just 100 items, there are more than 75 million unique samples of size five that can be drawn.

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