# KERNEL DENSITY ESTIMATION

## *ALIEN EMERGENCY!*

***Alien attacks are out of control! Cows keep disappearing in mysterious circumnstances. Stay safe! Use Kernel Density Estimation to understand alien behavior and save your cattle.***

## A STATISTICAL METHOD

Kernel Density Estimation (KDE) is a ***statistical tool*** that allows visualizing the ***probability distribution*** of an event through a ***smooth continuous curve***.
Based on the collected data we can explore the phenomenon of alien attacks.

## ARE MY COWS IN DANGER?

To answer this question you have to understand the probability of this event, meaning ***how likely it is to occur***. This can be visualized through a ***Probability Density Function*** (PDF).

## MORE ON THIS INNOVATION

In cases like caw mutilations, the ***PDF*** is unknown and needs to be estimated through empirical data. KDE achieves such estimation using ***kernels***: mathematical functions used to control the contribution of the dataset samples toward estimating the probability density of a new point.

## HOW TO BUILD THE KDE: STEPS AND TOOLS

### 1 PLACE POINT COLLECTION

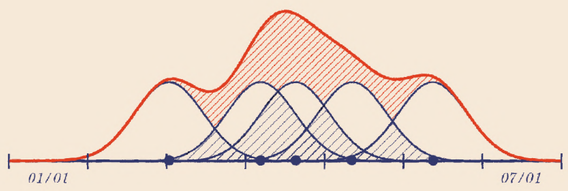
Let's consider the x-axis as the first seven days of January. ***For each stolen cow, place one on the day of disappearance***.


### 2 CENTER THE KERNELS

Define a kernel function – in this case it is Gaussian function – and ***draw a curve centered on each cow***.

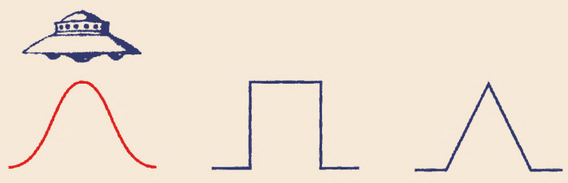

### 3 SUM THE KERNELS

Find the density plot by ***summing the kernel values from every cow.*** The more and closer cows are, the higher the probability density will be.




### ! DEFINING THE KERNEL

To build a KDE ***choose a kernel function***. Kernels can be of many kinds and each one affects the shape of the KDE curve differently. As the number of samples grows, the influence of the kernel shape becomes less important.

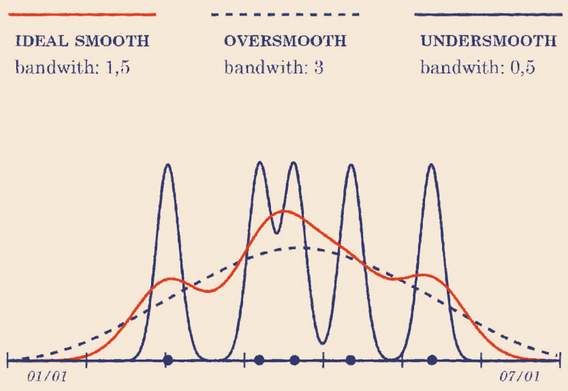



### ! CHOOSING THE BANDWIDTH

The bandwidth is a parameter that ***affects the "smoothness"*** of the resulting curve. It can be represented as how "wide" the initial kernel curve is. Choosing an optimal bandwith is ***fundamental for the representation quality***.

***Lower bandwidth:***
undersmoothing, the estimation is too detailed and not enough approximated.

***Higher bandwidth***:
oversmoothing, the estimation is too approximated to observe a trend.




## METHOD APPLICATION: ONE AND MORE DIMENSIONS

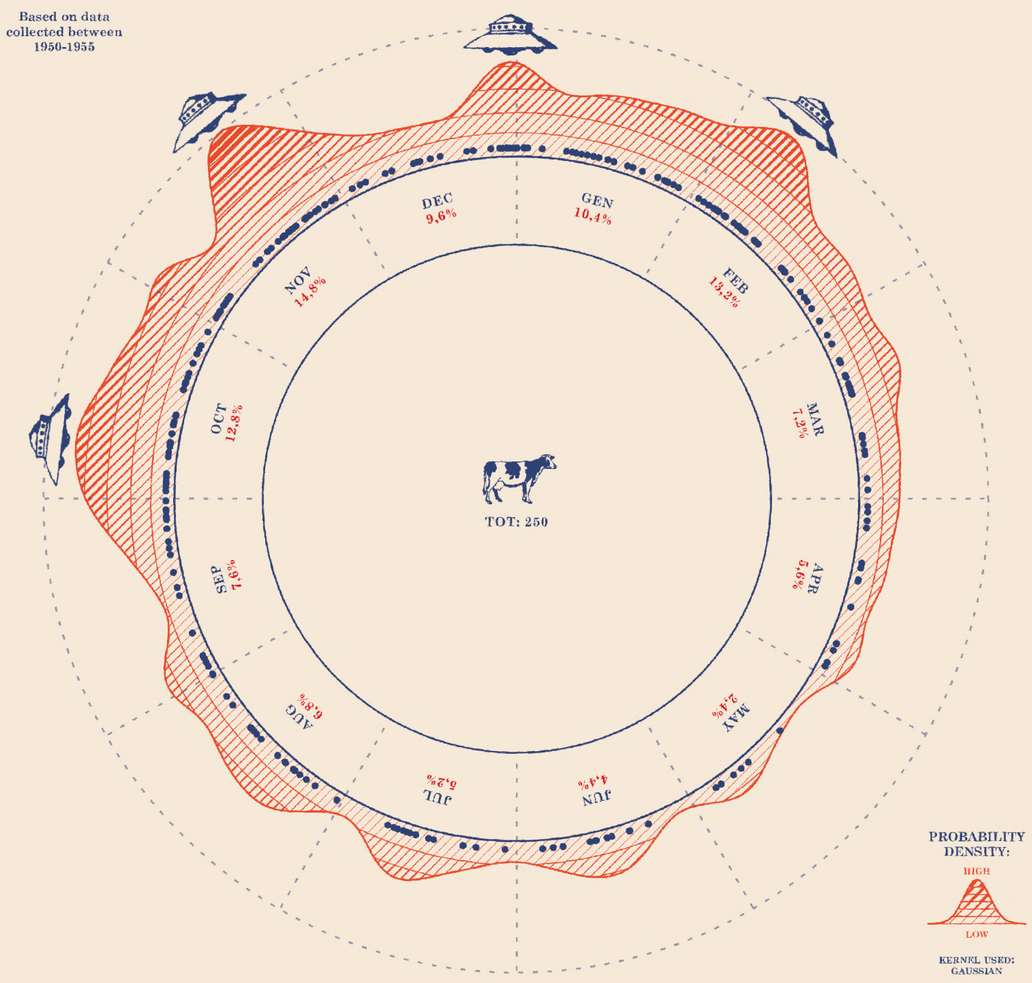
The graph below is a ***1-dimensional application*** of KDE. It visualizes the ***frequency of attacks over one year***. Since the time taken into consideration is periodical, the graph is circular.

***The area below the red curve is the probability*** of an alien attack on cows and it is equal to 1. It can be calculated even in a ***smaller portion of time***, such as a month, and it can be represented as a ***percentage.***

The contour map displays a ***2-dimensional application*** of the process. It portrays the ***location of attacks*** using two variables: latitude and longitude. When the number of variables grows, so does the dimensional complexity.

In this case the ***probability*** of having an alien attack in a location is ***represented by the volume below the surface***, which is organised in sections based on the probability density.

### WHEN DO ALIENS ATTACK?

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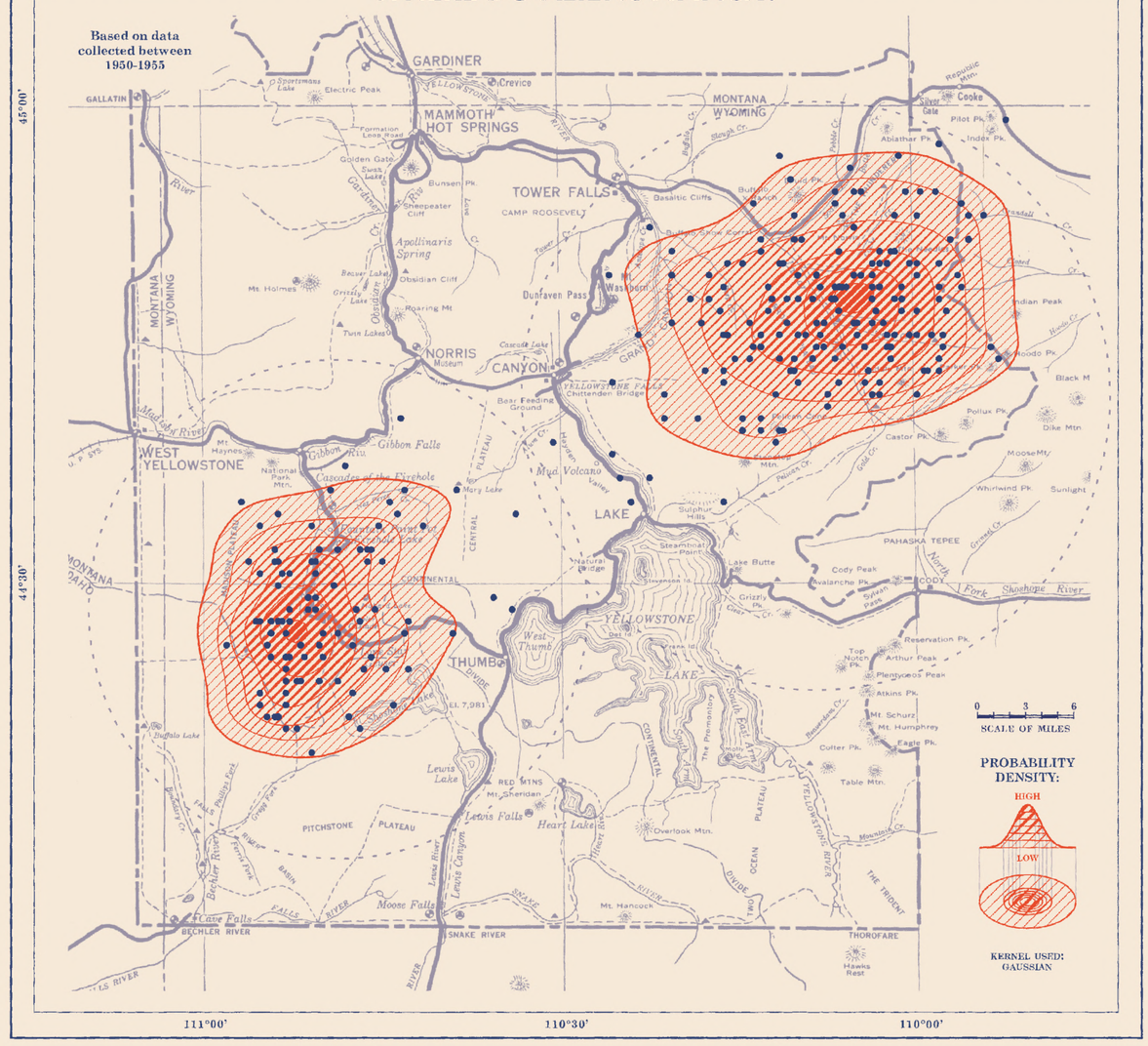


## LOOK AT THE CURVE AND TAKE ACTION!

***MEN! WOMEN! COWS!***
***BE CAREFUL, USE KDE!***

Thanks to KDE we now know which are the critical months: ***what happened in the past can be expected to happen in the future***. We recommend to be careful in winter: November and January are dangerous months, wherease spring is the safest time. North easters, pay attention! You are the most hit! If you want to find out more about alien behaviour you can ***apply KDE to more variables and create a multidimensional model***.

FEDERAL CIVIL DEFENCE ADMINISTRATION

VISUAL EXPLANATIONS OF STATISTICAL METHODS

**Kernel Density Estimation**


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