**Applications**

**SPAN**:

* Span can be used to find or locate the coordinates in vector space.
* It can be used to check which linear combinations are satisfied by the points of the vector space.
* To check linear dependency of the vectors.

**SUBSPACE**:

The theory of subspaces of n spaces is applied in the study of approximations. For example, whether a smooth real function can be approximated to a given level of accuracy by step functions or polynomial functions or trigonometric functions can be studied.

**DIMENSIONS**:

Dimensions have many applications as they occur frequently in common circumstances, namely wherever functions with values in some field are involved. They provide a framework to deal with analytical and geometrical problems, or are used in the Fourier transform. This list is not exhaustive: many more applications exist, for example in optimization. The minimax theorem of game theory stating the existence of a unique payoff when all players play optimally can be formulated and proven using vector spaces methods. Representation theory fruitfully transfers the good understanding of linear algebra and vector spaces to other mathematical domains such as group theory.

**ORTHOGONAL PROJECTIONS:**

* QR decomposition (Householder transformation and Gram–Schmidt decomposition);
* Singular value decomposition
* Reduction to Hessenberg form (the first step in many eigenvalue algorithms)
* Linear regression
* Projective elements of matrix algebras are used in the construction of certain K-groups in Operator K-theory
* It is also used in the separating axis theorem to detect whether two convex shapes intersect.

**GRAM SCHMIDT:**

• **QR Decomposition**

In linear algebra, a QR decomposition, also known as a QR factorization or QU

factorization is a decomposition of a matrix *A* into a product *A* = *QR* of an orthogonal

matrix *Q* and an upper triangular matrix *R*. QR decomposition is often used to solve

the linear least squares problem and is the basis for a particular eigenvalue algorithm,

the QR algorithm.

• **Functional Analysis**

Functional analysis is a branch of mathematical analysis, the core of which is formed by the

study of vector spaces endowed with some kind of limit-related structure (e.g. inner

product, norm, topology, etc.) and the linear functions defined on these spaces and

respecting these structures in a suitable sense. The historical roots of functional analysis lie

in the study of spaces of functions and the formulation of properties of transformations of

functions such as the Fourier transform as transformations defining continuous, unitary etc.

operators between function spaces.

• **Linear least squares Problem**

Mathematically, linear least squares is the problem of approximately solving

an overdetermined system of linear equations A x = b, where b is not an element of

the column space of the matrix A.

**NULL SPACE:**

* Room illumination. The range of A represents the area of the room that can be illuminated. The null space of A represents the power we can apply to lamps that don't change the illumination in the room at all.
* A set of map directions at the entrance to a forest. You can apply the directions to different combinations of trails. Some trail combinations will lead you back to the entrance. They are the null space of the map directions.

Think of an observer and n number of speakers at different distance and in directions. Now make a matrix of equations for sound from each speaker, based on contribution of their amplitude, frequencies and phase. Null space will be formed of all possible combination that you can set in a way that, the total/superimposed sound at observer location will be zero. Means, observer will not hear anything even if the speakers are playing.

**ROW / COLUMN SPACE:**

One of the most common application of Null space is in Rocket Thrusters. Here, the column space is the set of directions that we can achieve by the thrusters. If they're all perfectly functional then we can move in any direction. In this case our column space is the entire range. The null space are the set of thruster instructions that completely waste fuel. They're the set of instructions where the thrusters will thrust, but the direction will not be changed at all. Hence, by determining the Null spaces waste of fuel can be avoided. Basically, by finding the Null spaces one can avoid the parameters which show zero correlation with the operation and can achieve optimum results and reduce the wastage of resources.

**RANK-NULLITY THEOREM:**

* It is easy to highlight the need for linear algebra for physicists - Quantum Mechanics is entirely based on it. Also important for time domain (state space) control theory and stresses in materials using tensors.
* In circuit theory, matrices are used to solve for current or voltage. In electromagnetic field theory which is a fundamental course for communication engineering, conception of divergence, curl are important. For other fields of engineering, computer memory extensively uses the conception of partition of matrices. If the matrices size gets larger than the space of computer memory it divides the matrices into submatrices and does calculation.
* Matrices can be cleverly used in cryptography. Exchanging secret information using matrix is very robust and easy in one sense. How about MATLAB? This software is widely used in engineering fields and MATLAB's default data type is matrix. And, of course, Linear Algebra is the underlying theory for all of linear differential equations. In electrical engineering filed, vector spaces and matrix algebra come up often.
* Least square estimation has a nice subspace interpretation. Many linear algebra texts show this. This kind of estimation is used a lot in digital filter design, tracking (Kalman filters), control systems, etc.

**LEAST SQUARES METHOD:**

The most common application of this method, which is sometimes referred to as "linear" or

"ordinary", aims to create a straight line that minimizes the sum of the squares of the errors that are generated by the results of the associated equations, such as the squared residuals resulting from differences in the observed value, and the value anticipated, based on that model. Some applications include processing profilograms, estimation of chemical reaction population, automatic lens design and optical correction.