

Review Analytics Using K-Means and Natural Language Processing for Interpreting the Customer Sentiments

Rumana G. Mattoo¹, P S Metkewar², Nrashant Singh³, Ravi Chauhan⁴, Basant Tiwari⁵, Aafaq A. Rather^{6*}, Raeesa Bashir⁷

¹Department of Statistics, Govt. Degree College Ganderbal, Jammu and Kashmir, India.
Email: rumanaresearch@gmail.com

²School of Computer Science and Engineering, Department of Computer Science and Applications, Dr Vishwanath Karad MIT World Peace University, Pune - 411038, Maharashtra, India.
Email: pravin.metkewar@mitwpu.edu.in

³Department of Forensic Science, Amity University Dubai, UAE. Email: nsingh@amityuniversity.ae

⁴Symbiosis Institute of Computer Studies and Research (SICSR), Symbiosis International (Deemed University), Pune, India. Email: raviadmn143@gmail.com

⁵School of Computer Science and Engineering, Department of Computer Science and Applications, Dr Vishwanath Karad MIT World Peace University, Pune - 411038, Maharashtra, India.
Email: basanttiw@gmail.com

^{6*}Symbiosis Statistical Institute, Symbiosis International (Deemed University), Pune, India (Corresponding Author). Email: aafaq7741@gmail.com

⁷Department of Mathematics and Statistics, Vishwakarma University, Pune, India.
Email: raeesa.bashir@vupune.ac.in

ABSTRACT

Today, customer reviews are one of the most important areas for businesses to grow, by analysing their sentiments and understanding them. This research paper focuses on how customer reviews and feedbacks are helpful for businesses to grow. Authors say that the proposed methodology focuses on the collection of data from different sources and then applying pre-processing techniques, Exploratory data analysis (EDA), Natural Language Processing, sentiment analysis and fine-grained aspect-based analysis on that. Furthermore, this will help businesses to get proper insight from the customer dataset and as well as help businesses to focus more on the problems of customers stated by them in the reviews. Although this topic is already well studied, authors have chosen this topic to get the fine-grained aspect-based analysis of the customer reviews, as authors saw the research gap here, that the earlier studies focus solely on the customer reviews as a whole but not on the fine-grained aspect-based analysis. So, the authors will focus more on fine-grained aspects to bridge the research gap by incorporating machine learning and deep learning algorithms to associate sentiment scores with each aspect, hence, it will help to get good and accurate insights from the reviews.

Keywords: Customer review analytics, sarcasm detection, biased reviews, manipulated reviews, NLTK, K-Means Clustering.

How to cite this article: Mattoo RG, Metkewar PS, Singh N, Chauhan R, Tiwari B, Rather AA, Bashir R. Review Analytics Using K-Means and Natural Language Processing for Interpreting the Customer Sentiments. Int J Drug Deliv Technol. 2026;16(5): 1129-1136. DOI: 10.25258/ijddt.16.5.106

Source of support: Nil.

Conflict of interest: None.

1. Introduction

Cancer is a complex disease characterized by uncontrolled cell

proliferation and metastasis. Traditional chemotherapy, though effective in destroying rapidly dividing cells, often affects healthy tissues and produces severe side effects. To overcome these limitations, targeted drug delivery

systems have gained considerable attention in recent years. These systems aim to deliver therapeutic agents specifically to tumor cells, thereby increasing treatment efficacy and reducing systemic toxicity.

The development of targeted drug delivery has been accelerated by advancements in nanotechnology and molecular biology. Modern delivery systems can recognize tumor-specific markers, respond to environmental stimuli, and release drugs in a controlled manner. Such innovations have revolutionized cancer treatment and opened new opportunities for precision medicine.

2. Principles of Targeted Drug Delivery

Targeted drug delivery systems are designed to transport therapeutic agents directly to diseased tissues. The major objectives include improving drug bioavailability, reducing side effects, and enhancing therapeutic outcomes.

There are two primary targeting mechanisms:

1. **Passive Targeting:** Utilizes the enhanced permeability and retention (EPR) effect in tumor tissues, allowing nanoparticles to accumulate in tumors due to leaky vasculature.

Passive targeting is a drug delivery approach in which therapeutic agents accumulate naturally at the diseased site due to the physiological and pathological characteristics of tissues, especially tumors. It does not require specific ligand-receptor interactions for targeting.

Principle of Passive Targeting

Passive targeting mainly depends on the **Enhanced Permeability and Retention**

(EPR) effect, which is commonly observed in tumor tissues.

Enhanced Permeability and Retention (EPR) Effect

Tumor blood vessels are usually abnormal, highly permeable, and poorly organized. These leaky blood vessels allow nanoparticles and macromolecular drugs to pass through and accumulate within tumor tissues. In addition, tumors often have poor lymphatic drainage, which prevents efficient removal of these particles, leading to prolonged retention.

Mechanism of Passive Targeting

1. Drug carriers such as nanoparticles circulate in the bloodstream.
2. Due to leaky tumor vasculature, the carriers enter tumor tissues more easily.
3. Poor lymphatic drainage in tumors causes retention of the drug carriers.
4. The accumulated drug is gradually released at the tumor site.

Features of Passive Targeting

- Relies on natural physiological conditions
- No need for targeting ligands or antibodies
- Mainly used in cancer nanomedicine
- Enhances local drug concentration in tumors
- Reduces systemic toxicity

Nanocarriers Used in Passive Targeting

Common carriers include:

- Liposomes
- Polymeric nanoparticles
- Solid lipid nanoparticles
- Micelles
- Dendrimers

Advantages

- Simple design and formulation

- Improved drug accumulation in tumors
- Reduced side effects on healthy tissues
- Increased circulation time of drugs
- Better therapeutic efficacy

Limitations

- Variability of EPR effect among patients
- Poor penetration into deep tumor tissues
- Non-specific accumulation in organs like liver and spleen
- Limited effectiveness in certain tumor types

Applications in Cancer Therapy

Passive targeting is widely used in chemotherapy for delivering anticancer drugs such as doxorubicin, paclitaxel, and cisplatin through nanoparticle-based systems. Passive targeting is an important strategy in targeted drug delivery systems that utilizes the natural characteristics of tumor tissues to enhance drug accumulation. Although it has certain limitations, passive targeting remains a fundamental approach in modern cancer nanomedicine and has significantly improved the safety and effectiveness of cancer therapy.

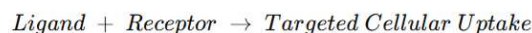
2. Active Targeting: Involves the attachment of ligands such as antibodies, peptides, or aptamers to drug carriers for specific recognition of cancer cell receptors.

Active targeting is an advanced approach in targeted drug delivery in which drug carriers are modified with specific ligands that can selectively bind to receptors or biomarkers present on target cells, particularly cancer cells. This

strategy enhances the precision and effectiveness of drug delivery.

Principle of Active Targeting

Active targeting is based on the specific interaction between ligands attached to the drug carrier and receptors overexpressed on diseased cells.



The ligand-receptor interaction facilitates selective binding and internalization of the drug carrier into target cells, improving therapeutic efficacy and minimizing damage to healthy tissues.

Mechanism of Active Targeting

1. Drug carriers are conjugated with targeting ligands.
2. The carriers circulate through the bloodstream.
3. Ligands recognize and bind to specific receptors on cancer cells.
4. The drug-loaded carrier enters the cell through receptor-mediated endocytosis.
5. The drug is released inside the target cell.

Common Targeting Ligands

Various ligands are used for active targeting, including:

- Monoclonal antibodies
- Peptides
- Aptamers
- Folic acid
- Transferrin
- Sugars and carbohydrates

Types of Receptors Targeted

Cancer cells often overexpress certain receptors such as:

- Folate receptors
- HER2 receptors
- Epidermal Growth Factor Receptors (EGFR)
- Transferrin receptors
- Integrin receptors

Advantages of Active Targeting

- High specificity toward cancer cells

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- Improved cellular uptake of drugs
- Reduced toxicity to normal tissues
- Enhanced therapeutic efficiency
- Lower drug dosage requirements
- Better patient outcomes

Limitations of Active Targeting

- Complex formulation methods
- High production cost
- Possible immune reactions
- Receptor variability among patients
- Limited penetration into solid tumors

Nanocarriers Used in Active Targeting

Commonly used carriers include:

- Liposomes
- Polymeric nanoparticles
- Dendrimers
- Micelles
- Antibody-drug conjugates

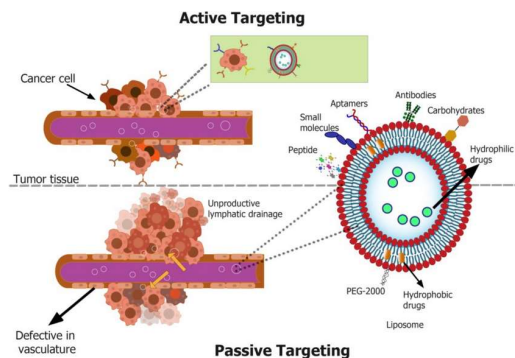
Applications in Cancer Therapy

Active targeting is widely used in:

- Breast cancer therapy
- Lung cancer treatment
- Targeted chemotherapy
- Gene therapy
- Immunotherapy

Examples include HER2-targeted therapies and antibody-drug conjugates used for selective cancer treatment.

Active targeting represents a highly efficient strategy in modern cancer therapy by enabling selective delivery of drugs to diseased cells through ligand-receptor interactions. This approach improves therapeutic outcomes, reduces systemic toxicity, and supports the development of precision medicine in oncology.



Targeted Drug Delivery Systems (TDDS) are advanced pharmaceutical approaches designed to deliver therapeutic agents specifically to diseased tissues or cells while minimizing effects on healthy tissues. The major objective is to improve therapeutic efficacy and reduce toxicity associated with conventional drug administration.

1. Selective Targeting

The primary principle of targeted drug delivery is selective localization of drugs at the desired site of action. This is achieved by recognizing specific biological markers or receptors present on diseased cells, especially cancer cells.

2. Controlled Drug Release

Targeted systems are designed to release drugs in a controlled and sustained manner. This helps maintain therapeutic drug concentration for an extended period and reduces the frequency of administration.

3. Enhanced Bioavailability

TDDS improve the bioavailability of drugs by protecting them from degradation in the biological environment and enhancing absorption at the target site.

4. Reduction of Side Effects

Conventional chemotherapy affects both normal and cancerous cells, leading to severe adverse effects. Targeted delivery minimizes systemic exposure and reduces toxicity to healthy tissues.

5. Passive Targeting

Passive targeting utilizes the natural physiological characteristics of diseased tissues. In cancer therapy, nanoparticles accumulate in tumor tissues through the Enhanced Permeability and Retention (EPR) effect due to leaky tumor blood vessels and poor lymphatic drainage.

6. Active Targeting

Active targeting involves attaching specific ligands such as antibodies, peptides, aptamers, or folic acid to drug carriers. These ligands bind selectively to receptors overexpressed on target cells, improving drug uptake.

7. Stimuli-Responsive Release

Modern targeted systems can respond to internal or external stimuli such as:

- pH changes
- Temperature
- Enzymes
- Magnetic fields
- Light

These stimuli trigger drug release specifically at the target site.

8. Use of Nanocarriers

Nanotechnology plays a crucial role in TDDS. Common nanocarriers include:

- Liposomes
- Polymeric nanoparticles
- Dendrimers
- Micelles
- Hydrogels
- Solid lipid nanoparticles

These carriers enhance drug stability, circulation time, and targeting efficiency.

9. Biocompatibility and Biodegradability

Drug carriers should be non-toxic, biocompatible, and biodegradable to ensure safety and avoid long-term accumulation in the body.

10. Improved Therapeutic Index

The therapeutic index refers to the balance between drug efficacy and toxicity. TDDS improve this balance by increasing drug concentration at the

target site while reducing exposure to normal tissues.

The **therapeutic index (TI)** is an important pharmacological parameter that indicates the safety and effectiveness of a drug. It represents the ratio between the toxic dose and the effective therapeutic dose of a medication.

$$\text{Therapeutic Index (TI)} = \frac{\text{Toxic Dose (TD)}}{\text{Effective Dose (ED)}}$$

A higher therapeutic index indicates that a drug is relatively safer because there is a larger margin between the effective dose and the toxic dose. In conventional chemotherapy, many anticancer drugs possess a narrow therapeutic index, meaning that the effective dose is very close to the toxic dose, resulting in severe side effects.

Role of Targeted Drug Delivery in Improving Therapeutic Index

Targeted Drug Delivery Systems (TDDS) improve the therapeutic index by selectively delivering drugs to diseased tissues while minimizing exposure to healthy cells. This enhances therapeutic efficacy and reduces systemic toxicity.

Mechanisms for Improvement

1. Site-Specific Drug Delivery

Targeted systems concentrate the drug at the tumor site, increasing the local drug concentration and improving treatment effectiveness.

2. Reduced Systemic Toxicity

Since the drug is directed mainly toward cancer cells, healthy tissues experience less exposure, reducing adverse effects such as:

- Hair loss
- Nausea
- Bone marrow suppression
- Organ toxicity

3. Controlled and Sustained Release

Controlled drug release maintains optimal therapeutic levels for longer durations, avoiding sudden toxic peaks in plasma concentration.

4. Enhanced Drug Stability

Nanocarriers protect drugs from premature degradation in the bloodstream, improving bioavailability and therapeutic action.

5. Improved Cellular Uptake

Active targeting using ligands, antibodies, or receptors enhances uptake by tumor cells, increasing drug effectiveness at lower doses.

Example in Cancer Therapy

Liposomal formulations such as doxorubicin-loaded liposomes improve the therapeutic index of anticancer drugs by reducing cardiotoxicity while maintaining anticancer activity.

Significance

Improvement in the therapeutic index leads to:

- Better patient compliance
- Higher treatment efficiency
- Lower toxicity
- Reduced hospitalization
- Enhanced quality of life

Improving the therapeutic index is one of the major goals of targeted drug delivery systems. By enhancing selective drug accumulation at diseased sites and minimizing toxicity to normal tissues, TDDS provide safer and more effective therapeutic outcomes, especially in cancer therapy.

3. Recent Trends in Targeted Drug Delivery Systems

Recent advancements in cancer therapy have introduced several innovative drug delivery platforms:

3.1 Nanoparticles

Nanoparticles are among the most widely used carriers in cancer therapy. Polymeric nanoparticles, metallic nanoparticles, and lipid-based nanoparticles offer improved drug

stability, controlled release, and enhanced tumor targeting.

3.2 Liposomes

Liposomes are phospholipid vesicles capable of encapsulating both hydrophilic and hydrophobic drugs. Liposomal formulations such as Doxil have shown reduced cardiotoxicity and improved therapeutic efficacy.

3.3 Dendrimers

Dendrimers are highly branched polymers with excellent drug-loading capacity. Their surface can be modified with targeting ligands for selective delivery to tumor cells.

3.4 Polymeric Micelles

Polymeric micelles improve the solubility of poorly water-soluble anticancer drugs and enhance circulation time in the bloodstream.

3.5 Stimuli-Responsive Systems

Smart drug delivery systems can release drugs in response to pH, temperature, enzymes, or magnetic fields present in tumor microenvironments.

3.6 Antibody-Drug Conjugates (ADCs)

ADCs combine monoclonal antibodies with cytotoxic drugs, enabling selective targeting of cancer cells while minimizing damage to normal tissues.

3.7 Gene and RNA-Based Delivery

The use of siRNA, mRNA, and CRISPR-based systems has opened new possibilities in cancer gene therapy and precision medicine.

4. Challenges in Targeted Drug Delivery

Despite remarkable progress, several challenges hinder the widespread clinical application of targeted drug delivery systems:

4.1 Biological Barriers

Drug carriers face barriers such as

immune clearance, poor tumor penetration, and instability in circulation.

4.2 Toxicity and Safety Concerns
Certain nanoparticles may produce long-term toxicity and undesirable immune responses.

4.3 Drug Resistance
Cancer cells can develop resistance mechanisms that reduce the effectiveness of targeted therapies.

4.4 Manufacturing and Scalability
Large-scale production of nanomedicines with consistent quality remains difficult and expensive.

4.5 Regulatory Issues
Strict regulatory guidelines and lack of standardized testing procedures delay clinical approval of novel delivery systems.

5. Future Perspectives

Future research in targeted drug delivery focuses on personalized medicine, artificial intelligence-assisted drug design, and multifunctional nanocarriers. The integration of imaging and therapeutic capabilities, known as theranostics, is expected to improve early diagnosis and treatment monitoring. Additionally, biodegradable and biocompatible materials are being developed to reduce toxicity and improve patient safety.

Advances in precision medicine and genomic profiling may enable the development of individualized therapies tailored to specific tumor characteristics. Such innovations are likely to transform cancer treatment in the coming decades.

6. Conclusion

Targeted drug delivery systems represent a significant advancement in cancer therapy by improving treatment specificity and reducing adverse effects.

Recent developments in nanotechnology, biomaterials, and molecular targeting have enhanced the efficiency of anticancer therapies. However, challenges related to toxicity, biological barriers, scalability, and regulation must be addressed before these systems can achieve widespread clinical success. Continued interdisciplinary research and technological innovation are essential for the future development of safe, effective, and personalized cancer treatments. The principles of targeted drug delivery focus on precise drug localization, controlled release, improved therapeutic efficiency, and reduced side effects. Advances in nanotechnology, molecular biology, and biomaterials continue to enhance the development of sophisticated targeted delivery systems for cancer and other diseases

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