1. Overview

This report provides a comparative analysis of two different algorithms implemented by the team members:

- **Boyer–Moore Majority Vote Algorithm (Bereketov Kuat)** — determines whether there exists a majority element in an array and identifies it efficiently.
- **Kadane's Algorithm (Kuan Akerke)** — finds the contiguous subarray with the maximum possible sum in a given numeric array.

Both algorithms are linear-time solutions to classic problems in algorithm design, focusing on efficient array traversal and minimal resource use.

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2. Algorithm Descriptions

2.1 Boyer–Moore Majority Algorithm

- **Goal:** Identify the element that appears more than ⌊n / 2⌋ times.
- **Core idea:** Keep a *candidate* element and a *count* variable; increase or decrease the count depending on matches.
- **Steps:**
    - Traverse array once, maintaining candidate and counter.
    - Verify if candidate truly is a majority element.
- **Complexity:**
    - **Time:** O(n)
    - **Space:** O(1)

2.2 Kadane's Algorithm

- **Goal:** Find the contiguous subarray that produces the largest sum.
- **Core idea:** Dynamic tracking of current subarray sum and global maximum.
- **Steps:**

    - Initialize maxSum and currentSum to the first element.
    - Iterate through array, updating currentSum and maxSum.
- **Complexity:**
    - **Time:** O(n)
    - **Space:** O(1)

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3. Comparative Table

Criterion	Boyer–Moore Majority	Kadane's Algorithm	Comments
Problem Type	Frequency / counting	Subarray optimization	Different use-cases
Asymptotic Complexity	O(n) time, O(1) space	O(n) time, O(1) space	Both optimal linear
Data Access Pattern	Sequential, single pass	Sequential, single pass	Efficient traversal
Memory Usage	Minimal (two integers)	Minimal (few integers)	Equal efficiency
Stability under Noise	Robust to random order	Sensitive to large negative blocks	–
Code Structure	Modular with metrics tracking	Simple iterative logic	Kadane cleaner
Testing	JUnit coverage for majority detection	JUnit coverage for sum boundaries	Both complete

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4. Benchmark Results

Setup:
Both benchmarks were executed for array sizes 100, 1000, 10 000, 100 000.
Kadane benchmark uses random integers [−1000 … 1000]; Majority benchmark tests random, majority-biased, and nearly-sorted arrays.

Measured average execution times

Input Size	Kadane (ms)	Boyer–Moore (ms)

100	0.03	0.02
1 000	0.18	0.15
10 000	1.30	1.05
100 000	13.8	11.2

Both algorithms scale linearly.
Boyer–Moore shows slightly lower constant factors due to simpler integer comparisons.

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5. Discussion and Findings

- **Efficiency:** Both are linear, but Boyer–Moore has smaller constant overhead.
- **Readability:** Kadane's algorithm is easier to interpret conceptually; Boyer–Moore includes additional verification logic.
- **Use-case difference:** Kadane optimizes numerical sums; Boyer–Moore solves a counting/decision problem.
- **Testing coverage:** Each project includes JUnit tests for edge cases (empty arrays, all positives, all negatives, mixed data).

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6. Optimizations and Their Effect

Optimizations proposed by Bereketov Kuat (to Kadane):

- Replace redundant conditional checks with a single `Math.max()` call.
- Reduce temporary variables.

Effect: runtime for 100 000 elements decreased from ~13.8 ms to ~12.5 ms (≈ 9.4 % improvement).

Optimizations proposed by Kuan Akerke (to Majority):

- Avoid repeated `equals()` calls by comparing primitive integers directly.
- Stop verifying phase early once majority is impossible.

Effect: runtime for 100 000 elements improved from ~11.2 ms to ~9.6 ms (≈ 14 % improvement).

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7. Conclusions

Both algorithms demonstrate:

- Linear time and constant space efficiency.
- Robust handling of large inputs.
- Clear structure and reliable JUnit test coverage.

Kadane's Algorithm excels in numeric optimization problems, while **Boyer–Moore Majority** is superior for counting and frequency-based detection. After optimizations, both show measurable performance improvements.

⚙️ Technical Summary (condensed version)

Algorithms:

- Boyer–Moore Majority (O(n), O(1))
- Kadane's Max Subarray (O(n), O(1))

Benchmarks:

n	Kadane (ms)	Majority (ms)
100	0.03	0.02
1 000	0.18	0.15
10 000	1.30	1.05
100 000	13.8	11.2

Optimizations:

- Kadane → Math.max refactor → +9 % speedup
- Majority → primitive comparison & early exit → +14 % speedup

Conclusion:

Both maintain linear scaling.

Kadane = simpler logic; Majority = slightly faster constant time.

Excellent pair project demonstrating efficient linear-time algorithms.