140509_46.md â€” AI-Enhanced Code Generation and Review Platform

> **Theme:** AI in Software Engineering Lifecycle
> **Mission:** Boost developer productivity and code quality via context-aware NLâ†’Code generation, automated tests, intelligent code review, and rich IDE/CI integrations.

README (Problem Statement)

Summary: Build a comprehensive platform that assists developers with code generation from natural language, automated testing, and intelligent code review across the development lifecycle.
Problem Statement: Deliver a platform that understands project context, integrates with IDEs and CI/CD, and suggests code aligned with standards while generating tests and performing high-signal reviews.

Steps:
- Natural language to code with context awareness
- Automated test generation & coverage analysis
- Intelligent review (bug/risk detection, optimizations)
- IDE plugins & workflow integrations
- Documentation generation/maintenance
- Quality metrics & technical debt assessment

Suggested Data: Large multi-language repos with tests and review comments; style guides; bug/patch histories.

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1) Vision, Scope, KPIs

Vision: Make high-quality software the default by embedding AI across design-build-test-review stages.
Scope:
- v1: NLâ†’Code, IDE plugin, static checks, unit test stubs, CI comments.
- v2: ML bug detector, integration tests, doc generation, refactoring suggestions.
- v3: Multi-repo context, architectural reviews, technical debt analytics.

KPIs:
- Suggestion acceptance rate â‰¥ 50%
- Auto-tests raise coverage â‰¥ 70% lines/branches on new code
- Review engine catches â‰¥ 80% of seeded bug patterns
- Dev cycle time â†“ 30% for target teams

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2) Personas & User Stories

- **Developer:** Inline NL prompts â†’ code; quick fix & refactor suggestions.
- **QA Engineer:** Auto-generated tests with reports & coverage gates.
- **Tech Lead:** Review dashboards, policy gates, debt trendlines.
- **Security Engineer:** SAST/secret scans with autofixes and PR annotations.

Stories:
- US-01: Generate a typed API client from an OpenAPI spec.
- US-06: Propose tests to cover edge cases identified by symbolic execution.
- US-12: PR review auto-flags SQL injection and suggests a parameterized fix.

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3) PRD (Capabilities)

1. **Context-Aware NLâ†’Code:**
    - Retrieves relevant files/snippets, types, API usage, and project style; supports

        Python/TS/Go/Java/C# in v1.
2. **Test Generation & Coverage:**
    - Unit/integration test synthesis (property-based where applicable); coverage & mutation testing reports.
3. **Intelligent Review:**
    - Static + ML: bug risk scores, concurrency/safety checks, performance tips, security rules (CWE/OWASP).
4. **IDE/CI Integration:**
    - VS Code/JetBrains plugins; inline diffs; CI bots with PR annotations and auto-fix PRs.
5. **Documentation:**
    - Docstrings, READMEs, architecture digests, change logs.
6. **Quality Metrics:**
    - Lint/complexity/duplication, coverage, hotspot detection, debt scoring.

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4) FRD (Functional Requirements)

- **RAG Context Server:** AST & symbol index, vector index over code/comments, dependency graph.
- **Prompt Builder:** Templates inject context (API signatures, tests failing, style rules).
- **Generators:** CodeGen, TestGen, DocGen with safety rails (no destructive shell, no secrets).
- **Review Pipeline:** SAST (Bandit/ESLint/semgrep), license checks, secret detection, ML classifiers for bug patterns.
- **CI Gates:** enforce min coverage, max complexity, security severities; staged approvals.
- **Policy Engine:** org/team rules (e.g., forbid eval/exec).
- **Telemetry:** acceptance, regressions, IDE latency; opt-in privacy.

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5) NFRD

- **Latency:** P95 suggestion â‰¤ 300 ms (cached context); â‰¤ 1.5 s cold.
- **Scale:** Repos up to 10M LOC; multi-repo context.
- **Security:** On-prem isolation; no code leaves tenant; SBOM for components.
- **Reliability:** 99.9% plugin service uptime.
- **Compliance:** SOC2/ISO27001; code retention policies.

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6) Architecture (Logical)

```
[IDE Plugin]  â†’  [Gateway]  â†’  [Context/RAG Server]  â†’  [Generators: Code|Test|Doc]
                                      |                     |
                                      v                     v
                              [Review Pipeline]      [Metrics Store]
                                      |                     |
                                      v                     v
                                  [CI Bot]            [Dashboards]
```

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7) HLD (Key Components)

- **Context Server:**
    - Build AST, symbol table, call graph; compute embeddings per symbol/file; elastic code search.
- **CodeGen:**
    - Large code LLM; decoding constrained by types & lints; temperature â‰¤ 0.2 by default.
- **TestGen:**
    - Path exploration (symbolic execution) + heuristics; property-based tests for pure functions.
- **Review Engine:**
    - Semgrep rules + ML risk model; taint analysis for sinks (SQL, SSRF, command).
- **DocGen:**
    - Generate docstrings from AST; summarize modules; Mermaid UML/sequence diagrams.
- **CI Bot:**
    - PR annotations, auto-fix patch generation, rollback/patch explainers.

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8) LLD (Selected)

Context Retrieval: - Build query with current file, cursor scope, imported types; fetch top-k symbols from vector index; include failing tests and lint findings.

Prompt Template (Python):

```
System: You are a senior Python engineer.
Context: <snippets+APIs+style+tests>
Task: Implement function {name} satisfying docstring and tests.
Constraints: PEP8, type hints, no external calls, raise ValueError on invalid input.
```

Review Rule (Semgrep):

```
rules:
- id: py.sql.injection.param
  pattern: cursor.execute($QUERY)
  message: Use parameterized queries.
  severity: ERROR
```

CI Gate (Coverage): - Fail PR if new/changed lines coverage < 70%.

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9) Pseudocode (End-to-End)

```
on_ide_request(prompt, cursor):
  ctx = retrieve_context(repo, cursor)
  code = codegen(prompt, ctx)
  tests = testgen(code, ctx)
  review = review_engine(code, ctx)
  docs = docgen(code, ctx)
  return bundle(code, tests, review, docs)

on_ci_pull_request(pr):
  metrics = run_checks(pr)
  if metrics.coverage < 0.7 or metrics.security.high > 0:
    annotate(pr, metrics)
    if can_autofix(metrics): create_autofix_pr(pr)
  else:
    approve(pr)
```

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10) Data & Evaluation

- **Training/Seeds:** BigCode/The Stack (filtered), CodeSearchNet, internal corpora with consent; review datasets (MSR, Google, GitHub PRs).
- **Metrics:** suggestion acceptance, edit distance to final, test coverage uplift, bug detection precision/recall, time-to-merge.
- **A/B:** team-level rollouts; guarded promotion via gates.

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11) Security & Governance

- PII/secret scrubbing; local inference option; reproducible builds; signed models; audit logs.
- License compliance checks; third-party component SBOMs.

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12) Observability & Cost

- Metrics: IDE latency, acceptance %, test gen time, CI queue times, GPU utilization.
- Cost controls: distillation, quantization, shared KV cache, batching; autoscale.

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13) Roadmap

- **M1 (4w):** IDE plugin + NLâ†'Code + static checks.

- **M2 (8w):** TestGen + CI bot + coverage gates.
- **M3 (12w):** ML bug model + DocGen + auto-fixes.
- **M4 (16w):** Multi-language scale + architectural reviews + debt analytics.

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14) Risks & Mitigations

- **Hallucinated code:** retrieval augmentation, constrained decoding, unit-test-first mode.
- **False positives in review:** precision-tuned rules, allow suppressions, human-in-loop.
- **Latency spikes:** warm pools, KV cache, local models.
- **IP concerns:** on-prem sealed deployment, data minimization.