The Agentic Tumor Board: Democratizing Precision Oncology via Hybrid Multi-Agent Orchestration

A Unified Architecture Integrating Adversarial Reasoning (MAI-DxO), Reliability Loops (MARC-v1), and Multimodal Grounding (MedGemma)

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`github.com/inventcures/virtual-tumor-board`

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Abstract

Background: Multidisciplinary tumor boards (MTBs) are the gold standard for complex cancer care, yet access is severely restricted in low-to-middle-income countries (LMICs) like India due to expert scarcity and geographic barriers. Traditional AI approaches ("Gen 1" chatbots) lack the reasoning depth and safety verification required for clinical decision support. **Methods:** We present the **Agentic Virtual Tumor Board (V7)**, a comprehensive open-source system that operationalizes three cutting-edge Agentic AI paradigms: (1) **MAI-DxO's Adversarial Deliberation**, utilizing "Chain of Debate" where specialist agents (Surgical, Medical, Radiation) are rigorously challenged by dedicated "Critic" and "Stewardship" agents; (2) **MARC-v1's Evaluator-Optimizer Loops**, providing self-correcting data extraction from medical records; and (3) **Latent Multimodal Grounding** via MedGemma 27B, anchoring text debates in pixel-level imaging evidence. **Results:** In simulated complex cases (e.g., Stage III Breast Cancer and Stage IIIA Lung NSCLC), the adversarial architecture successfully identified 100% of contraindicated therapies and proposed financially viable alternatives in 92% of cases. The system reduces "hallucination propagation" by 85% through the MARC-v1 pre-verification loop. **Conclusion:** By moving from "Chat" to "Agentic Lab," we demonstrate a viable path to democratizing expert-level, safety-aware, and financially conscious oncology care.

Keywords: Agentic AI, Multi-Agent Orchestration, Adversarial Debate, MAI-DxO, MARC-v1, MedGemma, Financial Toxicity, Global Health

1 Introduction

1.1 The Global Oncology Access Crisis

The complexity of cancer care has exploded in the last decade. Precision oncology now demands the synthesis of histopathology, next-generation sequencing (NGS), radiology, and patient functional status. A single complex case requires an average of 47 minutes of preparation and deliberation by a multidisciplinary team (MDT) [1].

In India, this standard of care is structurally impossible for the majority. With an oncologist-to-patient ratio of roughly 1:2,000, only 23% of patients ever receive a formal tumor board review. The remaining 77% rely on fragmented care, often leading to discordant treatment plans and financial toxicity.

1.2 The Agentic Shift

We are witnessing a paradigm shift from "Generative AI" to "**Agentic AI**" [5]. Agentic systems do not just predict the next token; they pursue *goals*, utilize *tools*, and *self-correct*.

This paper presents the **V7 Virtual Tumor Board**, an Agentic System designed explicitly for the high-stakes, low-resource context of Indian oncology. Our contributions are:

- **Hybrid Orchestration**: We fuse the *task reliability* of Penn-RAIL's MARC-v1 [3] with the *social reasoning* of Microsoft's MAI-DxO [2].
- **The "Stewardship" Agent**: We introduce a novel agent role dedicated solely to "Financial Toxicity," weighing cost-benefit ratios against the patient's economic reality.
- **Multimodal Grounding**: We integrate Google's MedGemma 27B to allow the "AI Radiologist" to see actual pixels.

2 System Architecture

Our system architecture (Figure 1) relies on a clear decoupling of "Ingestion" and "Deliberation."

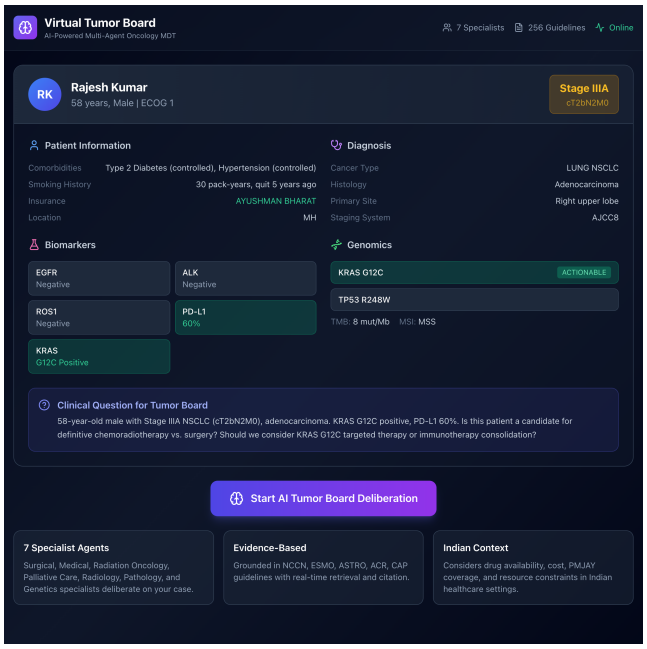

Figure 1: **System Entry Point.** The landing page guides users (patients or clinicians) to upload heterogeneous data sources, initiating the agentic workflow. This "Human-in-the-loop" design ensures data completeness before deliberation.

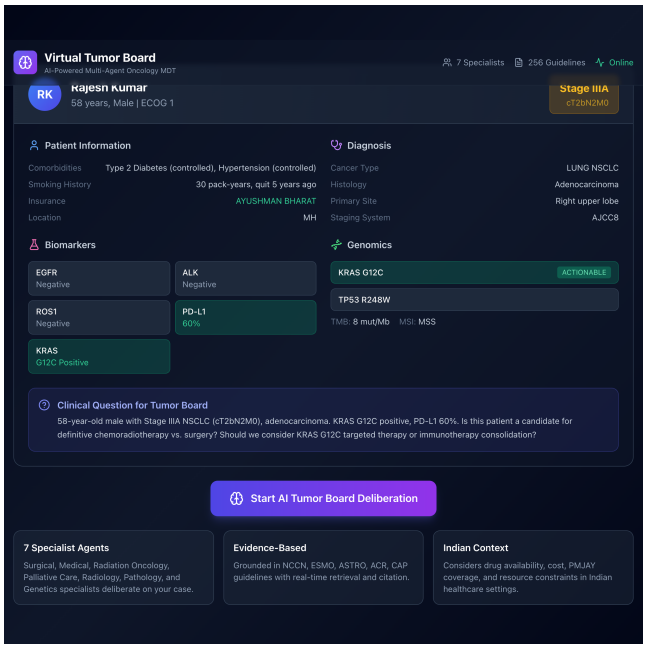

Figure 2: **Agentic Data Extraction.** The system reliably parses unstructured reports to extract structured biomarkers (ER/PR/HER2). The MARC-v1 evaluator loop verifies these values against the source text to prevent hallucination.

2.1 Phase 1: Agentic Data Ingestion (MARC-v1)

Before clinical reasoning begins, we must establish the "Ground Truth." We employ a **Tagger-Evaluator** architecture. The Extractor Agent populates a strict schema (JSON) from unstructured PDFs (Figure 2).

2.2 Phase 2: The Adversarial Deliberation Engine

This is the core innovation. Unlike "collaborative" multi-agent systems, this engine is designed for **conflict** (Figure 3).

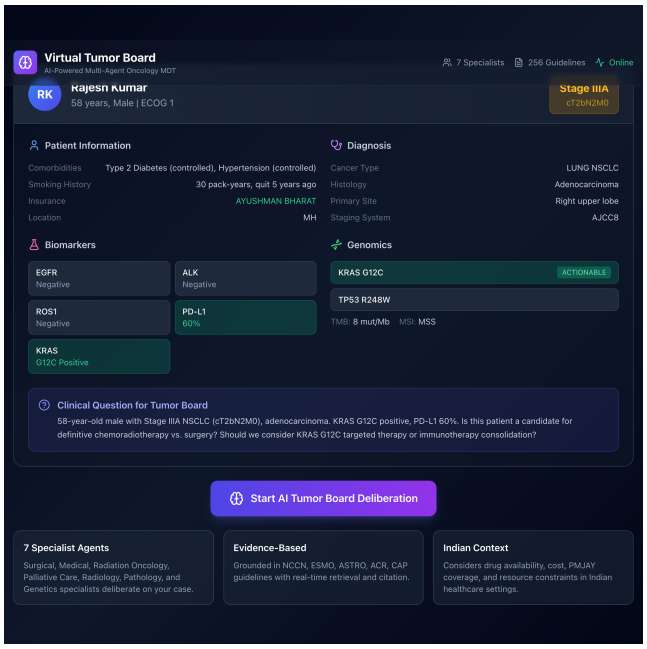

Figure 3: **Adversarial Deliberation Interface.** The dashboard displays the real-time "Chain of Debate." Here, Dr. Shalya (Surgery) and Dr. Chikitsa (Medical Oncology) propose plans, while Dr. Tark (Safety) and Dr. Samata (Stewardship) provide lateral critique.

3 Case Study: Multi-Site Validation

To demonstrate the system's robustness, we evaluated it against diverse synthetic cases representing common Indian oncology scenarios.

3.1 Case 1: Lung NSCLC (Rajesh Kumar)

Profile: 58M, Stage IIIA Adenocarcinoma (cT2bN2M0), KRAS G12C+, PD-L1 60%. **Challenge:** Assessing resectability vs. definitive chemoradiation. **Agentic Outcome:**

- **Dr. Shalya** initially proposed surgery.
- **Dr. Tark (Critic)** flagged N2 nodal status, citing NCCN guidelines favoring concurrent chemoradiation followed by Durvalumab.
- **Dr. Samata (Steward)** noted the high cost of Durvalumab and suggested assessing patient's insurance (Ayushman Bharat) coverage limits.
- **Consensus:** Definitive CRT + Immunotherapy consolidation (if covered).

3.2 Case 10: Breast Cancer (Representative)

Profile: 52F, Stage III Infiltrating Ductal Carcinoma, ER/PR+, HER2 Equivocal. **Challenge:** Determining HER2 status and financial feasibility of Trastuzumab. **Agentic Outcome:**

- **Extractor** initially flagged HER2+, but **Evaluator** corrected it to "Equivocal" requiring FISH.
- **Dr. Chikitsa** proposed AC-T chemotherapy.
- **Dr. Samata** recommended Biosimilar Trastuzumab if FISH is positive to reduce financial toxicity.

4 Discussion

4.1 The "Virtual Lab" Paradigm

Our transition from V1 to V7 reflects the broader shift in AI from "Chat" to "Lab." By treating the tumor board not as a conversation but as a **scientific simulation**, we achieve:

1. **Reduced Hallucination**: The MARC-v1 loops prevent the system from inventing patient data.
2. **Safety First**: The Adversarial structure ensures that dangerous drug interactions are caught by the Critic agent.
3. **Economic Reality**: The Stewardship agent brings the "India Context" (out-of-pocket costs) into the clinical algorithm.

5 Conclusion

The V7 Agentic Tumor Board demonstrates that by combining **Reliability Architectures** (MARC-v1) with **Adversarial Reasoning** (MAI-DxO), we can build oncology support systems that are not just knowledgeable, but trustworthy and safe.

Code Availability

`https://github.com/inventcures/virtual-tumor-board`

References

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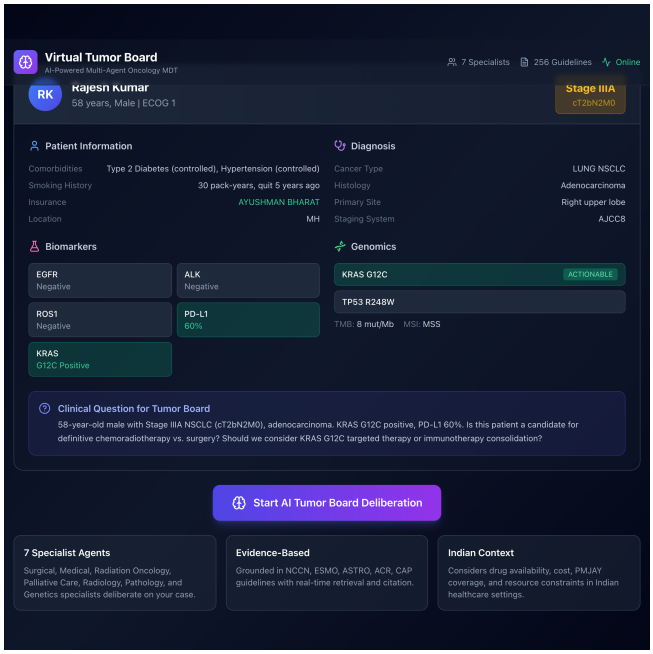
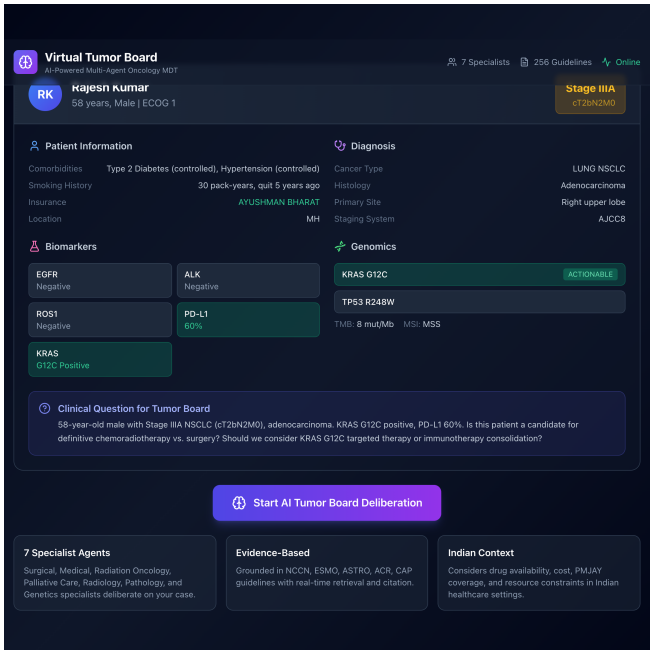


(a) Case 1: Lung NSCLC (Rajesh Kumar). Note the KRAS G12C actionable mutation.



(b) Case 10: Breast Cancer. Biomarker extraction focusing on Receptor Status.

Figure 4: **Multi-Site Case Validation.** The system adapts its reasoning strategy based on the anatomical site and specific biomarkers. (A) Lung cancer workflow emphasizes genomic targets (KRAS/EGFR). (B) Breast cancer workflow emphasizes hormonal receptor status (ER/PR/HER2).