Streaming Haptic Feedback in Multiplayer VR Games via 5G: Unlocking Ultra-Low-Latency Tactile Immersion

Omar Abdellatif¹

Contents

1	Intr	oduction	4	
	1.1	Background and Motivation	4	
	1.2	Virtual Reality and Haptics as Emerging Interfaces	4	
	1.3	The Role of 5G in Next-Gen Interactive Systems	4	
2	From Virtual Worlds to Physical Feedback			
	2.1	How Haptics Bridges Cyber and Physical	4	
	2.2	Feedback Loops in Real-Time Immersive Systems	4	
	2.3	Challenges in Synchronizing Multisensory Input	4	
3	5G Technologies for Low-Latency Interaction			
	3.1	Ultra-Reliable Low-Latency Communication (URLLC)	4	
	3.2	Edge Computing and Network Slicing	4	
	3.3	Latency Benchmarks for Haptic Transmission	4	
4	System Architecture for Haptic Streaming			
	4.1	Multiplayer VR Setup Overview	4	
	4.2	Sensors, Actuators, and Data Flows	4	
	4.3	End-to-End Latency Considerations	4	

¹ omar.abdellatif@stud.hshl.de

2 Omar Abdellatif

5	Use	Case: Tactile Feedback in a VR Game	4
	5.1	Gameplay Scenario and Network Load	4
	5.2	Evaluation of Responsiveness and Immersion	4
	5.3	Limitations and Bottlenecks	4
6	Secu	urity and Reliability Concerns	4
	6.1	Protecting Physical Feedback Streams	4
	6.2	Error Handling in Tactile Loops	4
	6.3	Future-Proofing with Protocol Standards	4
7	Outlook and Future Applications		
	7.1	Beyond Gaming: Remote Surgery, Robotics, Training	4
	7.2	The Path Toward the Tactile Internet	4
	7.3	6G and AI for Smarter Physical Interaction	4
8	Con	clusion	4
	8.1	Key Takeaways	4
	8.2	Final Thoughts on Immersive Cyber-Physical Systems	4
9	Decl	aration of Originality	4

Abstract: Text



1 Introduction

- 1.1 Background and Motivation
- 1.2 Virtual Reality and Haptics as Emerging Interfaces
- 1.3 The Role of 5G in Next-Gen Interactive Systems
- 2 From Virtual Worlds to Physical Feedback
- 2.1 How Haptics Bridges Cyber and Physical
- 2.2 Feedback Loops in Real-Time Immersive Systems
- 2.3 Challenges in Synchronizing Multisensory Input
- 3 5G Technologies for Low-Latency Interaction
- 3.1 Ultra-Reliable Low-Latency Communication (URLLC)
- 3.2 Edge Computing and Network Slicing
- 3.3 Latency Benchmarks for Haptic Transmission
- 4 System Architecture for Haptic Streaming
- 4.1 Multiplayer VR Setup Overview
- 4.2 Sensors, Actuators, and Data Flows
- 4.3 End-to-End Latency Considerations
- 5 Use Case: Tactile Feedback in a VR Game
- 5.1 Gameplay Scenario and Network Load
- 5.2 Evaluation of Responsiveness and Immersion
- 5.3 Limitations and Bottlenecks
- 6 Security and Reliability Concerns
- 6.1 Protecting Physical Feedback Streams
- 6.2 Error Handling in Tactile Loops
- 6.3 Future-Proofing with Protocol Standards
- 7 Outlook and Future Applications
- 7.1 Beyond Gaming: Remote Surgery, Robotics, Training
- 7.2 The Path Toward the Tactile Internet
- 7.3 6G and AI for Smarter Physical Interaction

sentences quoted literally are marked as such; other references with regard to the statement and scope are indicated by full details of the publications concerned. The paper and work in the same or similar form have not been submitted to any examination body and have not been published. This paper was not yet, even in part, used in another examination or as a course performance. I agree that my work may be checked by a plagiarism checker.

Date&Place - Maria Cron

Bibliography