

Java im Neuland von GenAI und Vector Search

Wie kann man mit Vektordatenbanken die Ergebnisse von GenAI Prompts verbessern ?

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Serge Ndong

Seine Schwerpunkte im beruflichen Alltag liegen in der Softwareentwicklung mit Java und JavaScript. Das dabei erworbene Know-how gibt er gerne als Berater und Trainer weiter. Neben Softwaretechnik inspiriert ihn die Arbeit mit anderen Entwicklern, Anwendern und Stakeholdern



Christian Dedek

Seit zwei Jahrzehnten in der Umsetzung, Realisierung, Modernisierung bzw. Migration unternehmenskritischer Systeme tätig.



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GenAI für Java Devs

100% Local, open source, Java, no ML,
no cloud, no fees, no membership, ...



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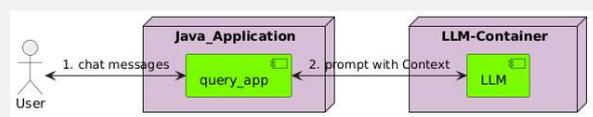
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Chat LLM Szenario

LangChain4J

Docker

Ollama



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Code

```
<dependency>
  <groupId>dev.langchain4j</groupId>
  <artifactId>langchain4j</artifactId>
  <version>0.30.0</version>
</dependency>

<dependency>
  <groupId>dev.langchain4j</groupId>
  <artifactId>langchain4j-ollama</artifactId>
  <version>0.30.0</version>
</dependency>

<dependency>
  <groupId>ch.qos.logback</groupId>
  <artifactId>logback-classic</artifactId>
  <version>1.5.3</version>
</dependency>
```

```
<dependency>
  <groupId>org.testcontainers</groupId>
  <artifactId>testcontainers</artifactId>
  <version>1.19.6</version>
  <scope>compile</scope>
</dependency>
```



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Code

```
public class HelloWorldLLM { new *

    static String MODEL_NAME = "orca-mini"; // try "mistral", "llama2", "codellama", "phi" or "tinylama" 2 usages
    static GenericContainer<?> ollama = new GenericContainer<>("langchain4j/ollama-" + MODEL_NAME + ":latest") 3 usages
        .withExposedPorts(11434);

    public static void main(String[] args) { new *
        ChatLanguageModel model = OllamaChatModel.builder().baseUrl(baseUrl()).modelName(MODEL_NAME)
            .timeout(Duration.ofMinutes(10))
            .build();

        Assistant assistant = AIServices.builder(Assistant.class)
            .chatLanguageModel(model) // it should use ollama LLM
            .chatMemory(MessageWindowChatMemory.withMaxMessages(20))
            .build();

        // let's start the conversation with the assistant.
        startConversationWith(assistant);
    }

    static String baseUrl() { 1 usage new *
        ollama.start();
        return String.format("http://%s:%d", ollama.getHost(), ollama.getFirstMappedPort());
    }
}
```



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Live Demo

```

How to configure the reactive x509 authentication with spring security?
18:51:32.318 [main] INFO d.a.javaforumstuttgart.Assistant - =====
18:51:51.731 [main] INFO d.a.javaforumstuttgart.Assistant - Assistant: To configure Reactive X509 Authentication with Spring Security, follow these steps:
18:51:51.731 [main] INFO d.a.javaforumstuttgart.Assistant - Assistant: To configure Reactive X509 Authentication with Spring Security, follow these steps:
1. Add the following configuration section to your web.xml file to configure the hostname, port number, and authentication method:
...
<security-config>
  <login-config>
    <auth-method>reactiveX509Authentication.X509</auth-method>
  </login-config>
  <http-config>
    <form-login-config>
      <default-target-url>/home</default-target-url>
    </form-login-config>
    <logout-config>
      <logout-url>/logout</logout-url>
    </logout-config>
  </http-config>
</security-config>
...
2. In your application code, call the 'reactiveX509Authenticator()' function with the configuration section as an argument to initialize the authenticator.
3. Once the authenticator is initialized, call the 'authenticate()' method on the authenticator to authenticate against the server. This will return a certificate object that you can use to verify the authenticity of the server's identity.
I hope this helps! Let me know if you have any further questions.
  
```

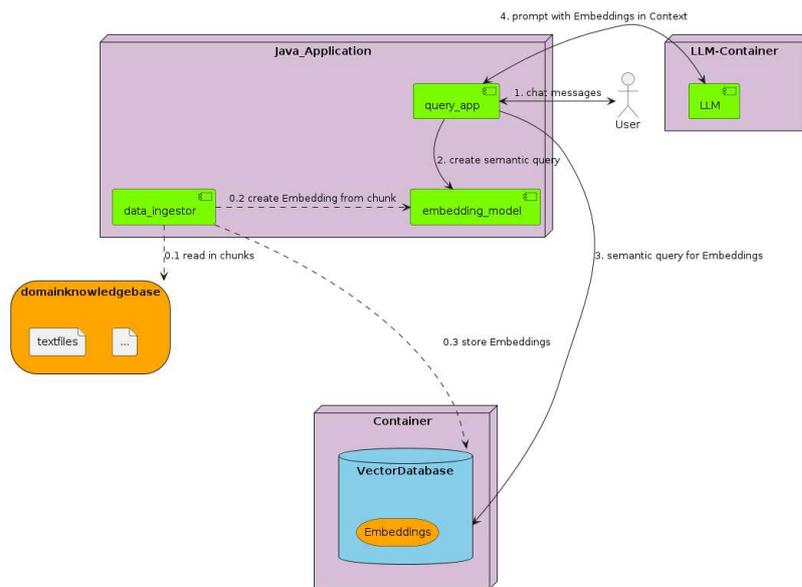
```

19:02:17.424 [main] INFO d.a.javaforumstuttgart.Assistant - =====
19:02:17.424 [main] INFO d.a.javaforumstuttgart.Assistant - User:
who is the president of senegal?
19:02:56.208 [main] INFO d.a.javaforumstuttgart.Assistant - =====
19:02:56.208 [pool-1-thread-1] DEBUG d.l.rag.DefaultRetrievalAugmentor - Routing query 'who is the *president of senegal?' to the following retriever: dev.l
langchainj.rag.content.retriever.EmbeddingStoreContentRetriever@1c2eebd6
19:02:56.208 [pool-1-thread-2] DEBUG d.l.rag.DefaultRetrievalAugmentor - Retrieved 2 contents using query 'who is the *president of senegal?' and retriever
'dev.langchainj.rag.content.retriever.EmbeddingStoreContentRetriever@1c2eebd6'
19:03:19.726 [main] INFO d.a.javaforumstuttgart.Assistant - =====
19:03:19.726 [main] INFO d.a.javaforumstuttgart.Assistant - Assistant: The President of Senegal is currently Macky Sall.
19:03:19.726 [main] INFO d.a.javaforumstuttgart.Assistant - =====
19:03:19.726 [main] INFO d.a.javaforumstuttgart.Assistant - User:
  
```



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Retrieval Augmented Generation



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Live Demo Hello RAG

- Laden eines Dokumentes, das wir für das RAG benutzen wollen
- LangChain4j bietet integrierte Unterstützung für das Laden von Dokumenten aus verschiedenen Quellen:
 - Dateisystem, URL, Amazon S3, Azure Blob Storage, GitHub, Tencent COS
- LangChain4j das Parsen mehrerer Dokumenttypen:
 - Text, pdf, doc, xls, ppt.

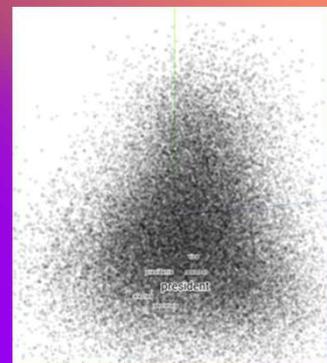
```
DocumentParser documentParser = new TextDocumentParser();  
Document document = loadDocument(toPath(documentPath), documentParser);
```



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VektorDBs

Next GenDB ?



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Vector Databases - Architekturmittel



Relational

Structured Data
Adhoc Queries



NoSQL

Scale out
Document based
Key Value



Graph

Complex Relationships
Networks
Hierarchical



Vector

Unstructured Data
Semantic Search

- Use Cases
 - Long-term memory for LLMs
 - Semantic search
 - search based on the meaning or context
 - Similarity search
 - Text
 - Images
 - Audio
 - Video
 - Recommendation engines



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Vector Databases – new Tool Market

- Pinecone
 - COTS (founded 2019) ex AWS/Yahoo
 - Gartner Cool Vendor (2021)
- Weaviate
 - OS
 - Mature
 - Viele Integrationen
- Chroma
 - OS/Python
 - easy API
 - JS Support
- Milvus
 - OS/Python
 - scale out (10exp9-Vectoren ?)
- PostgreSQL
 - Extension
- Redis
 - Extension
- Qdrant
 - OS/Rust
- Vespa
 - OS/ex Yahoo Division (2017)
- ..



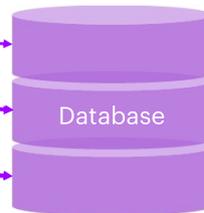
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VektorDBs – Warum nicht relational speichern ?

- Unstrukturierte Daten > 80%

- Images
- Video
- Audio
- Social media posts
- Long Text



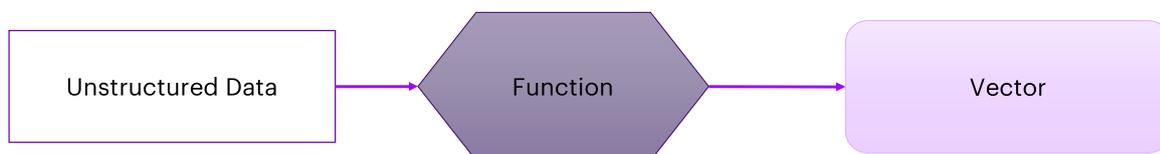
- Suchfunktionalität

- Kategorisierung ?
- Klassifizierung ?
- Automatische Metadaten ?



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Datenrepräsentation als n-Dimensionaler Raum = Embeddings



Bassirou Diomaye Faye, running in place of Ousmane Sonko, was elected president with 54% of the vote, while Amadou Ba, the candidate of the ruling United in Hope (BBY) coalition, peacefully conceded defeat.

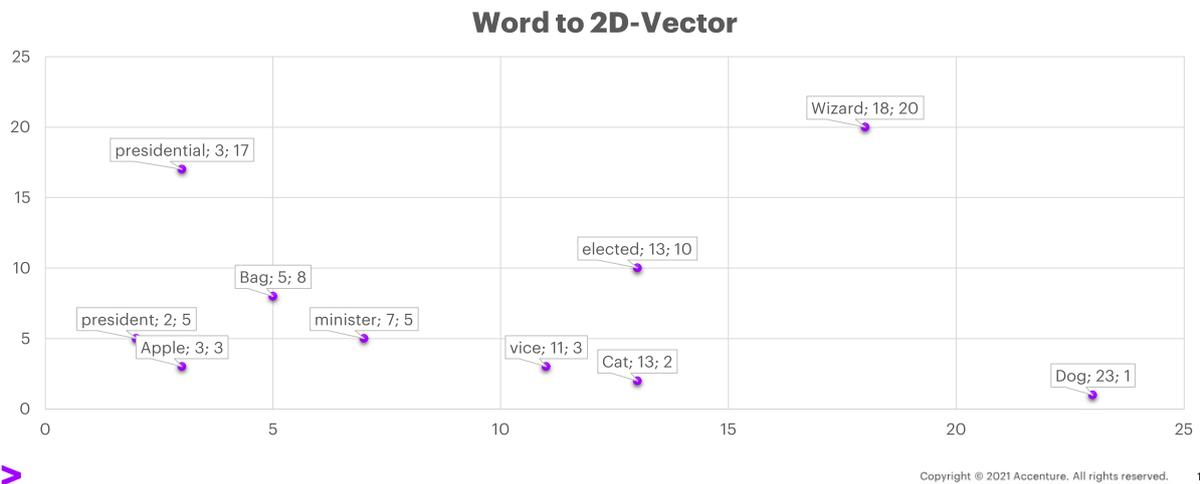
[0.1, 0.2, 0.9, 0.4, 0.7, ...]



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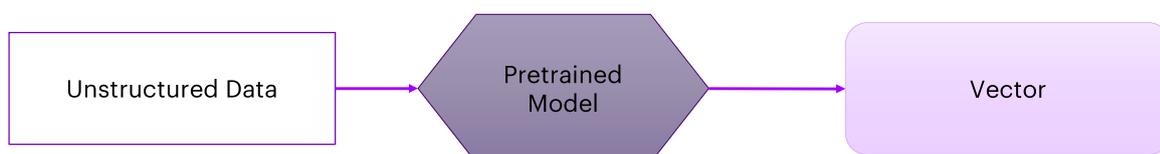
Text als Vektor präsentieren

Naive Embedding function



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Datenrepräsentation als n-Dimensionaler Raum = Embeddings



Bassirou Diomaye Faye, running in place of Ousmane Sonko, was elected president with 54% of the vote, while Amadou Ba, the candidate of the ruling United in Hope (BBY) coalition, peacefully conceded defeat.

[11.1, 17.2, 100.9, 11.4, 0.9, ...]

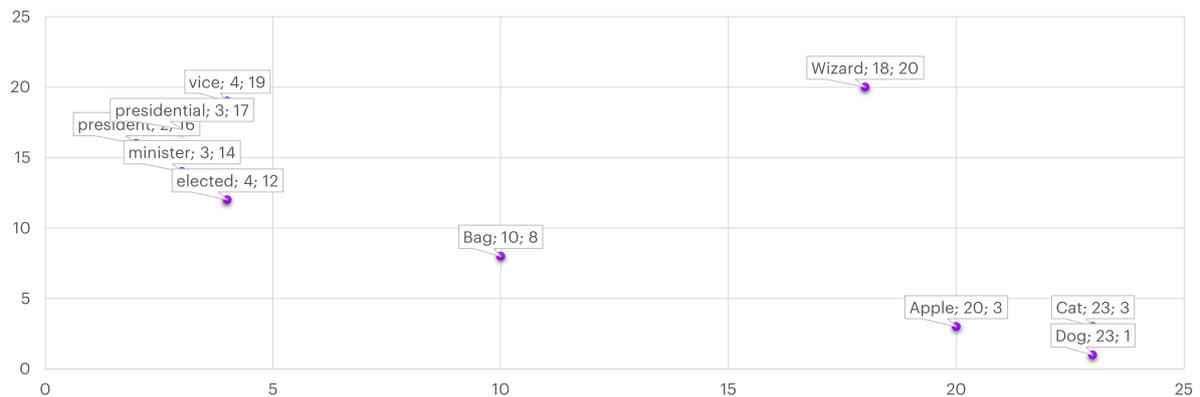
>

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Embedding Models

Text in möglichst kurzem Vektor abbilden und trotzdem die korrekte Distanzrelation von Vektoren erhalten

Word to 2D-Vector



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Embedding Modelle

Pretrained Models

- Text
 - BERT, DistilBERT, word2vec, DialoGPT
- Vision
 - Resnet, alexnet, vgg, squeezenet, densenet
- Audio
 - Wav2vec, mxnet-audio
- SourceCode
 - code2vec

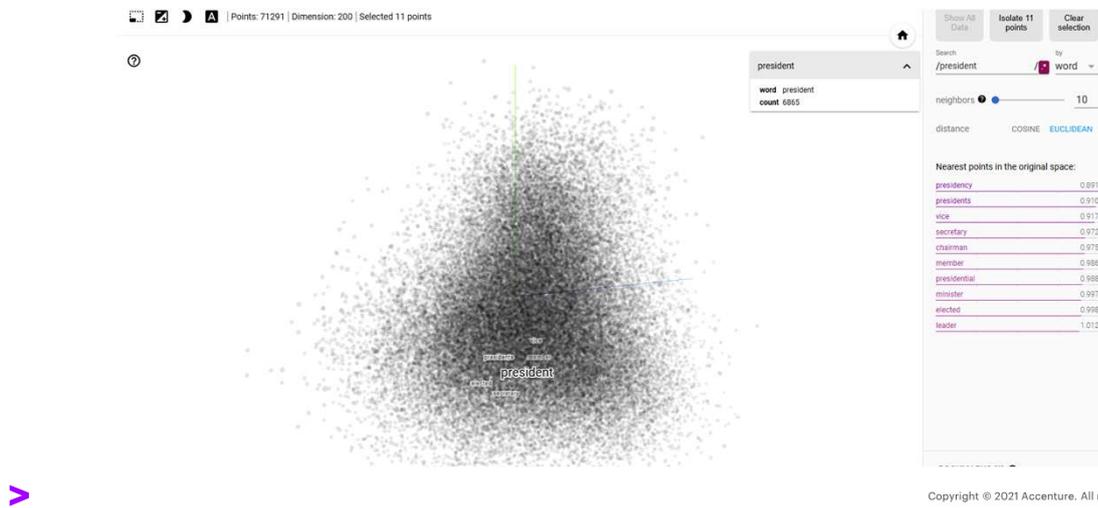


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Beispiel „President“-Word Embedding

200 Dimensionen auf 3D-Projektion



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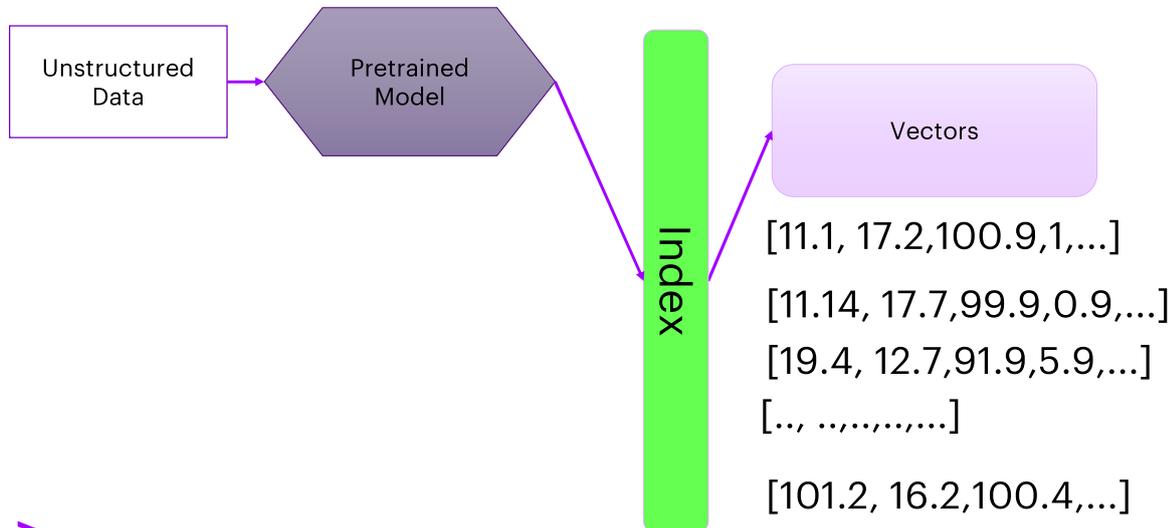
Similarity Search

- Approximate Nearest Neighbour-Search (ANN-Search)
 - Basieren auf einer Abstandsfunktion
 - semantisch
 - Kontextuell
 - ??
- Verschiedene Rechenverfahren
 - Euklidisch
 - Cosinus
 - Jaccard
 - Hamming
 - Inneres Produkt
 - ..

>

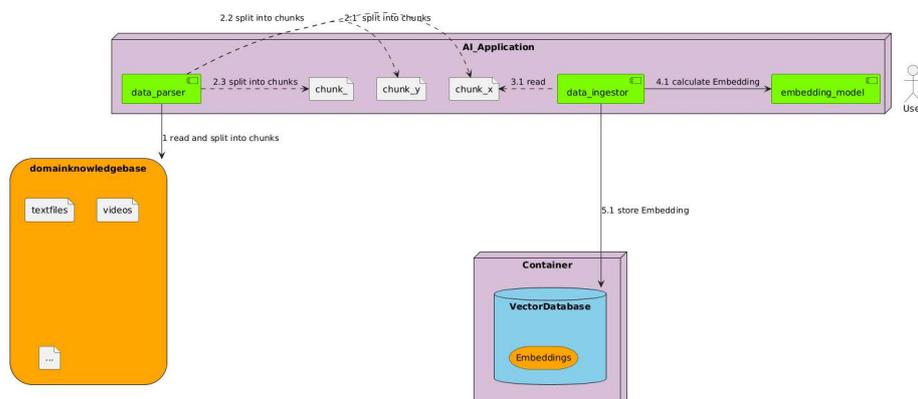
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VectorDB Indexing



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VectorDB Ingestion



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Demo1 Parser

```
TextSegment { text = "00000+V0|0L@C0JNY6,000000W L0ta
F0T40x0y00000'zi0LP006'0Y00X00'00000[002Sn0000 0000Q00z'[00(00A0j0-E0\0n(
0'0=00<I-000'00
00k/qUqf00000R;0300000YGJ000
00X0ShE0<+700F|0|80tym000700LXhio0, 0H00DVu0+0'700>50lq000000RPy0n000XJTz0&0~000-4m00000k0f0A00Q0" metadata = {absolute_directory_path=/mnt/c/Schulung/Ja
vaMagazin/Java4GenAI/JavaForumStuttgart/target/classes, file_name=2024_Senegalese_presidential_election.pdf, index=15} }
```



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Demo2 Parser Ingest Text Segment and Vector

```
##### Segment: TextSegment { text = "Faye's victory is the first instance that an opposition candidate won an election in the first round since
Senegal's independence in 1960.[93] Faye was officially inaugurated as president on 2 April.[100]" metadata = {absolute_directory_path=/mnt/c/Schulung/JavaM
agazin/Java4GenAI/JavaForumStuttgart/target/classes, file_name=2024_Senegalese_presidential_election.pdf, index=141} }
##### Segment: TextSegment { text = "The annual Independence Day parade in Dakar on 4 April was cancelled, with authorities citing the
uncertainty caused by the election campaign.[101]" metadata = {absolute_directory_path=/mnt/c/Schulung/JavaMagazin/Java4GenAI/JavaForumStuttgart/target/clas
ses, file_name=2024_Senegalese_presidential_election.pdf, index=142} }
```

```
[0.04568881, 0.087896295, -0.00624974, -0.0067684003, 0.02102884, 0.0115616545, -0.05412227, 0.03177354, -0.021385618, 0.023854485, 0.04573811, -0.0194224
0.01376256, 0.009371487, 0.0031882265, 0.007280579, -0.02273725, -0.03370268, -0.004755333, 0.02654764, 0.0018355298, 0.027214473, -0.02536649, 0.046
0188, -0.013454461, 0.0237086, 0.04032829, -0.029298116, -0.0542669, -0.0215131, 0.05007749, -0.00949838, -0.056454755, -0.03201396, -0.0218
1547, 0.0014646389, 0.02357473, 0.02454211, 0.035026174, -0.0034597933, 0.025889242, -0.05058951, -0.044460215, 0.01213263, -0.04061244, -0.074758925, 0.0
0033852, 0.009665141, -0.0738304, 0.07203488, 0.016167485, -0.008625264, -0.032566243, 0.01076847, -0.009995809, 0.00855222, 0.039545074, 0.02050493, -0.
4341689, 0.061048366, 0.04993234, -0.19964601, 0.009364372, -0.010575395, 0.00813087, 0.005225033, -0.1062341, -0.025635583, -0.0127580175, -0.0155034205,
0.02612450, 0.006698655, -0.16527278-4, -0.029912004, -7.0290695E-4, -0.00826123, -0.01361754, -0.040428214, 0.0017004223, -0.0063119023, 0.03367316, 0.0
642322, 0.02024362, 0.014712215, -0.044013828, 0.060238905, 1.9843725E-4, -0.262792E-4, 0.007086267, 0.03187263, 0.018853225, 0.071177546, 0.034233083, -0.
003384, 0.002722695, 0.0072515076, 0.006193483, 0.0027128092, 0.32131654, -0.029595433, 0.012046861, 0.01526835, 0.021288302, -0.00269925, -0.041679103,
0.006961127, 0.2410605E-4, 0.011500899, 0.012981342, 0.04640685, -0.046566524, 0.10726091, 0.017311616, 0.010118486, 0.0112999715, -0.01665465, 0.031644195
-0.09589433, 0.07601748, -0.045986145, -0.013470189, 0.06813661, 0.033581417, -6.986662E-5, 0.07713946, 0.038001005, 0.15981604, 0.029046103, -0.03271688,
0.018514346, -0.06407412, 0.006765275, -0.046232965, 0.024604987, 0.055721135, -0.0024619042, -0.024632972, 0.041624915, -0.039226227, 0.00775898, -0.0491
0406, -0.050219045, 0.02360921, 0.023392726, -0.026028397, -0.01190281, 0.02694057, 0.004534056, 0.073741784, -0.002834948, 0.032179048, -0.020554015, 0.0
527872, 0.03223758, 0.0091258, -0.0317476, 0.037920754, -0.039622746, 0.0093883155, 0.006082748, -0.0654256, -0.021463955, 0.06384041, -0.006686104, -0.0067
69, -0.050014986, 0.03217882, -0.013122229, -0.011243983, -0.03733835, 0.00904717, 0.056786088, 0.006294668, 0.14032665, 0.011237619, 0.0049625, 0.0408584
7, -0.0012718613, 0.010593088, 0.09065858, -0.01544015, 0.030802488, 0.010904799, 0.006458572, -0.01802814, -0.00483988, 0.055679698, 0.023100996, 0.02257
546, -0.04330186, 0.040444274, -0.04224069, -0.02275224, 0.006641671, -0.024764868, -0.058755744, -0.062449983, 0.07361122, -0.010655133, -0.031920827, -0.
014220676, -0.0322085, 0.041934763, 0.02093386, 0.010800549, 0.02932213, 0.021836635, -0.009528055, 0.0064231465, 0.013503717, 0.030231074, 0.013596953,
0.08046571, 0.07930787, 0.014815567, -0.05093396, 0.035844184, -0.0491417647, -0.053997644, 0.048262604, -0.017928623, 0.041533787, -0.2831168, 0.01492468,
0.02174235, -0.0152497515, -0.030879042, 0.0060709266, 0.06086184, -0.010439319, -0.002272622, 0.07914631, 0.015080033, 0.004172042, 0.010628397, 0.07608998
-0.013537099, -0.015334029, -0.052178505, -0.016640974, -0.03109041, -0.0453905, -0.01247088, 0.016012734, -0.02443716, -0.102639486, 0.004763745, 0.
0054518776, 0.09276623, 0.011001155, -0.05536231, 0.023871958, -0.022114849, 0.109706104, -0.008826915, -0.00722456, 0.047993485, 0.004534346, 0.01763354
0.003793392, -0.04101186, -0.0438681, 0.057068665, 0.018084302, 0.0034759145, 5.784203E-4, 0.042616347, -0.0021137927, -0.00262106, 0.07302106, 0.030665
3, 0.028077506, -0.024655386, -0.053936789, 0.11429864, -0.011340915, 0.00272186, 0.04781613, -0.05812472, 0.03147357, 0.03933176, 0.0291389, 0.0135602
8, -0.0022723977, 0.010352388, 0.036347784, -0.045013107, 0.048273876, -0.01299374, -0.028572816, -0.026273737, 0.06718335, -0.0033858744, 0.15063071, -4.8
70252E-4, -0.003683975, 0.00808406, 0.02833881, 0.018700577, -0.010479729, 0.05613582, -0.00519917, 0.059383688, -0.00725506, 0.032871186, -0.05901815, -
0.032326407, -0.024178555, 0.011222135, 9.789444E-4, -0.02670642, -0.045742128, 0.034592796, 0.0038165913, -0.015821261, 0.051339504, 0.03296446, -0.0690318
-0.2501752, -0.0042489883, -0.02315018, -0.029292549, 0.056754533, 0.015527129, -0.040185977, 0.038341087, -0.00774871, -0.056563344, -0.00442244, 0.0123
074, 0.022574856, -0.00235903, 0.008025218, 0.00459086, -0.008090988, -0.030127104, 0.037030294, -0.07048064, -0.3327865E-4, 0.06708397, 0.013079685, 0.0
4257079, -0.03701763, 0.04099959, -0.01628222, 0.01933267, -0.03731716, -0.030525316, -0.037921023, -0.050800856, -0.036010806, -0.038386436, 0.025967143,
0.021680268, 0.012777855, 0.040228106, 0.06218795, -0.05537446, -0.017812848, -7.137819E-4, 0.053091808, -0.039547065, 0.050922725, -0.020070276, -0.004262
07, 0.015040737, -0.009626144, -0.01382740, 0.010030221, -0.00247296, -0.03022506, 0.027366262, -0.00824064, 0.009348173, -0.00909297, -0.024052438,
0.042214442, -0.021696614, 0.023083754, 0.017156744, -0.0021777372, -0.00745457, 0.038882507]
```



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Demo3 Parser Result

```
--> Result TextSegment 97. "Senegal's little-known opposition leader Bassirou Diomaye Faye is named the next president" (https://apnews.com/article/senegal-election-polls-1a9ab8ceab4ecde9b9cce412717dce31). AP. 25 March 2024. Archived (https://web.archive.org/web/20240327003841/http Score --> 0.8829769857986469
```

```
--> Result TextSegment Bassirou Diomaye Faye, running in place of Ousmane Sonko, was elected president with 54% of the vote, while Amadou Ba, the candidate of the ruling United in Hope (BBY) coalition, peacefully conceded defeat.[8] Faye's victory was later confirmed by Senegal's Supreme Court.[9] He was inaugurated Score --> 0.8771153704060703
```



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Demo RAG 2

```
--> Result TextSegment 97. "Senegal's little-known opposition leader Bassirou Diomaye Faye is named the next president" (https://apnews.com/article/senegal-election-polls-1a9ab8ceab4ecde9b9cce412717dce31). AP. 25 March 2024. Archived (https://web.archive.org/web/20240327003841/http Score --> 0.8829769857986469
--> Result TextSegment Bassirou Diomaye Faye, running in place of Ousmane Sonko, was elected president with 54% of the vote, while Amadou Ba, the candidate of the ruling United in Hope (BBY) coalition, peacefully conceded defeat.[8] Faye's victory was later confirmed
```



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Demo1 Segments

```
19:07:35.011 [main] DEBUG d.l.s.e.EmbeddingStoreIngstor - Starting to embed 4629 text segments
Exception in thread "main" java.lang.IndexOutOfBoundsException: Index 0 out of bounds for length 0
    at java.base/jdk.internal.util.Preconditions.outOfBounds(Preconditions.java:64)
    at java.base/jdk.internal.util.Preconditions.outOfBoundsCheckIndex(Preconditions.java:70)
    at java.base/jdk.internal.util.Preconditions.checkIndex(Preconditions.java:248)
    at java.base/java.util.Objects.checkIndex(Objects.java:374)
    at java.base/java.util.ArrayList.get(ArrayList.java:459)
    at dev.langchain4j.model.embedding.OnnxBertBiEncoder.weightedAverage(OnnxBertBiEncoder.java:180)
    at dev.langchain4j.model.embedding.OnnxBertBiEncoder.embed(OnnxBertBiEncoder.java:76)
    at dev.langchain4j.model.embedding.AbstractInProcessEmbeddingModel.embedAll(AbstractInProcessEmbeddingModel.java:50)
    at dev.langchain4j.store.embedding.EmbeddingStoreIngstor.ingest(EmbeddingStoreIngstor.java:193)
    at dev.langchain4j.store.embedding.EmbeddingStoreIngstor.ingest(EmbeddingStoreIngstor.java:150)
    at de.accentventure.javaforumstuttgart.vectordatabase.InMemoryEmbeddingParserSpringSecurity.main(InMemoryEmbeddingParserSpringSecurity.java:49)
```



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Demo2 SegmentSize Ingest

```
TextSegment { text = "The first thing you need to do is add the following filter declaration to your web.xml file:
<filter>
<filter-name>springSecurityFilterChain</filter-name>
<filter-class>org.springframework.web.filter.DelegatingFilterProxy</filter-class>
</filter>

<filter-mapping>
<filter-name>springSecurityFilterChain</filter-name>
<url-pattern>/*</url-pattern>
</filter-mapping>" metadata = {absolute_directory_path=/mnt/c/Schulung/JavaMagazin/Java4GenAI/JavaForumStuttgart/target/classes, file_name=spring-security-reference.pdf, index=1392} }
TextSegment { text = "This provides a hook into the Spring Security web infrastructure. DelegatingFilterProxy is a Spring Framework class which delegates to a filter implementation which is defined as a Spring bean in your application context. In this case, the bean is named "springSecurityFilterChain", which is an internal infrastructure bean created by the namespace to handle web security. Note that you should not use this bean name yourself. Once you've added this to your web.xml, you're ready to start editing your application context file. Web security services are configured using the <http> element." metadata = {absolute_directory_path=/mnt/c/Schulung/JavaMagazin/Java4GenAI/JavaForumStuttgart/target/classes, file_name=spring-security-reference.pdf, index=1393} }
TextSegment { text = "18.2.2. A Minimal <http> Configuration

All you need to enable web security to begin with is

<http>
<intercept-url pattern="/*" access="hasRole('USER')"/>
<form-login />
<logout />
</http>" metadata = {absolute_directory_path=/mnt/c/Schulung/JavaMagazin/Java4GenAI/JavaForumStuttgart/target/classes, file_name=spring-security-reference.pdf, index=1394} }
```



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Demo3 SegmentSize Result

--> Rel Chapter 26. Reactive X.509 Authentication
 Similar to Servlet X.509 authentication, reactive x509 authentication filter allows extracting an authentication token from a certificate provided by a client.

Below is an example of a reactive x509 security configuration:

```
@Bean
public SecurityWebFilterChain securityWebFilterChain(ServerHttpSecurity http) {
    http
        .x509(withDefaults())
        .authorizeExchange(exchanges -> exchanges
            .anyExchange().permitAll()
        );
    return http.build();
} Score --> 0.9359036156226233
```



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Demo RAG 3

21:07:35.911 [main] INFO d.a.javaforumstuttgart.Assistant - Assistant: The reactive x509 authentication configuration in spring security uses the WebClient library to perform mutual TLS and X.509 authentication. Here's an example of configuring the security web filter chain using the WebClient library:

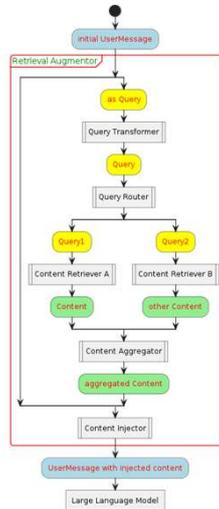
```
@Bean
public SecurityWebFilterChain securityWebFilterChain(ServerHttpSecurity http) {
    WebClient webClient = WebClient.create();
    webClient.http().client(new HttpMethodBuilder() {
        public HttpMethod buildGet() {
            return get("/path");
        }
    });
    X509AuthorizationStrategy strategy = new X509AuthorizationStrategy();
    strategy.setCertificate("/path/to/certificate");
    SecurityWebFilterChain chain = webClient.filter(http)
        .authorizeExchange(new AuthorizeExchange<>(strategy))
        .build();
    return http.build();
}
```

This configuration sets up a client using the WebClient library to perform a GET request to the root URL of the application. The X509AuthorizationStrategy is used to extract an authentication token from the provided certificate, and then the security web filter chain is built using this information.



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RAG Flow



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Wrap up

Warum sollte eine so alte „Anwendungsentwicklungssprache“ wie Java bei GenAI zum Einsatz kommen?

Antworten auf die Frage hängen eng mit Fragen nach der Zukunft von Mensch-Maschine-Schnittstellen im Allgemeinen zusammen. Kommt es hier zu einem Paradigmenwechsel, werden wir keine klassischen Anwendungen mehr bauen, dann wird sich die Frage nach Anwendungsprogrammierern nicht mehr stellen. Für den nicht weniger wahrscheinlichen Fall, dass wir auch 2030 noch Applikationen warten und betreiben, dürfte es interessant sein, ob wir z. B. KI-Komponenten mit Java über Python oder direkt in unsere Java-Architekturen integrieren werden.



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**Bewaffnet mit klugen
Vorüberlegungen wagen wir uns
ins GenAI-Land. Es wird Zeit, sich
die Hände schmutzig und die Füße
nass zu machen.**



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Thank You

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